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## SYMPOSIUM ON FRACTURES AND DISLOCATIONS

*Under the Direction of Dr Fremont A Chandler*

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### INJURIES OF THE CARPAL BONES

KELLOGG SPEED, M D , F A C S \*

#### PRESENT DAY SIGNIFICANCE

THE necessities of military service and industrial war work have forced surgeons both in and out of service to a closer acquaintance with injuries of the carpal bones. Considerable information on the pathology of these injuries has accumulated in the last twenty five years, rational treatment has been established and become reasonably orthodox. In some areas specific information regarding these lesions from the men now treating the injuries has been lacking. Although most if not all of these surgeons would agree that their knowledge of and treatment for the common fracture of the lower end of the radius the most frequently encountered injury near the wrist and the first cousin of carpal fractures, was satisfactory from all standpoints their knowledge of carpal injuries is small. Clean cut interpretation of these carpal injuries by the roentgenologist, and the adoption of a workable standard of description or clinical classification have lagged behind the progressive study of the lesions undertaken by a small group of men in various parts of the world. At this time surgeons meeting these injuries daily in their work believe they are entering new fields, in reality they are merely observing their patients more closely and are being forced by need for manpower to understand definitely why apparently small and often unrecognized injuries lead to prolonged and painful disability. These surgeons require time for

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reading and review, for clinical education in injuries of the carpus. There is plenty of information in the literature awaiting adaptation to clinical problems and practical results.

A return of men to manual labor, whether digging in fox holes, taking boot training, working in the machine shops and factories, struggling with artillery in the field and on the road or the many dangerous chances of hand and wrist injury found in airplane service, has resulted in a large number of carpal injuries. Murray Meekison in a year's service in the Air Corps encountered about 110 fractures of the navicular as enumerated in his report of June 1, 1944. My friend Colonel L. H. McKim as Consulting Surgeon of the Canadian Army in two years has encountered 125 navicular fractures—all healing without a single instance of nonunion. Other men have reported smaller groups here and there, the aggregate is quite large. The proportion of these injuries will be maintained for a long time, and fortunately the oncoming surgeon will now recognize them easily and in so doing will treat them successfully.

#### ANATOMICAL CONSIDERATIONS

The anatomy of the bones, their encasing ligaments, their articular surfaces and synovial coverings, their range of movement and their all-important blood supply must be known.

Without this knowledge

the acute

may well

dislocation, and he consequently may be unable to apply the best use of treatment.

The carpal bones are divided clinically into two principal rows or groups. The *proximal row* contains the os naviculare, the os lunatum and the os triquetrum. The *distal row* comprises the os hamatum, os capitatum, os multangulum majus and minus and the os pisiforme. Omitting the distal radioulnar joint from discussion of the wrist we find that the radiocarpal joint is condylod. "Forcing into this joint are the lower end of the radius and the triangular disk

which fit into the

of the wrist. The articular

surfaces are covered with cartilage and the joints are surrounded by strong capsular ligaments enhanced by interlacing dorsal and volar radiocarpal, intercarpal and two lateral ligaments the radial and ulnar collateral ligaments. Flexor and extensor tendons crossing the carpus, bound by the annular ligaments of the wrist, further strengthen and protect the carpal joints and maintain a powerful attachment of the hand to the forearm.

Through the attachments of these ligaments comes the blood supply of the carpal bones from small terminal volar and dorsal branches of

the ulnar and radial arteries and the metacarpal vessels. No blood vessels enter the bones on the articular or smooth cartilaginous surfaces. The blood supply to carpal bones is consequently scant and not uniform but may vary with individuals or the different bones. The navicular has a wide natural variation of its blood supply, both in location and quantity, which may enter as a factor in its healing or necrosis after fracture or injury.

Most of the radiocarpal motion occurs between the radius and proximal row of carpal bones both in a volar-dorsal axis and in lateral play. There is much less motion between the two rows of carpal bones at the midcarpal joint and still less at the distal margin or carpo-metacarpal joint. The amount of this motion was described by me in 1925 (See monograph<sup>7</sup> or textbook).

### INCIDENCE

The occurrence of carpal bone injuries is about one eighth to one-tenth of all fractures of the wrist including Colles' fracture. In order of occurrence the injuries are fractures of the navicular in various parts of its body, dislocations of or around the lunate bone, fractures of the lunate, fractures of the navicular plus dislocations, injuries of the triquetrum and complicated fracture dislocations involving the proximal row and the midcarpal and radiocarpal joints. Isolated fractures or dislocations of or around the bones of the distal row are quite rare but must be looked for.

### ETIOLOGY

The cause may be a *fall* on the outstretched hand such as causes Colles' fracture. In the face of the obvious fracture of the radius and its demonstration by the roentgenogram the surgeon may very easily overlook an accompanying injury of the carpal bones. This is particularly so because the first film made soon after the accident may fail to show a definite plane or line of fracture across the injured carpal bone as has been observed in many injuries of the navicular. The cause may be a *minor blow* or even a *twist of the wrist*, under pressure or strain. It may be forgotten by the recipient. Later symptoms and findings bring out the pain and disability of real bone injury and the roentgenogram finally shows the fracture plane or the resulting change of density of fragments or aseptic necrosis, usually resulting from interfered with blood supply and enforced use or lack of rest and splintage.

Apparently minor injuries of the carpus must consequently receive careful and complete physical and x ray examination at the time of injury. They may profitably, in the face of real complaint of pain or local tenderness be put at rest on a splint with the hand in neutral position and re examined after one or two weeks or later by roent-



genogram for late-appearing planes of fracture, even when no primary separation of fragments is found. Later one looks for evidence of necrosis of parts of the bone involved resulting from changed vascular supply as betrayed by changes in density compared to neighboring bones. As a matter of fact the navicular is the worst offender in this class of injury, because it is the most often injured carpal bone, because it has the greatest range of movement in the carpus, because its blood supply is the most variable and because on account of its anatomical situation it is subject to the greatest strain and compressions. Direct violence from blows on the wrist may likewise cause these injuries, often without open wounds.

The violence of the cause may lead to a mere crack across the bone involved—most often the navicular—with resulting pain which may interfere with functional use of the hand and yet may fail immediately afterward to show displacement of fragments, comminution or compression, or most unfortunately, even the finest line of fracture in the roentgenogram. Sometimes this line is so faint, so indefinite that it is considered by both roentgenologist and surgeon as a normal marking of the bone and is, at least temporarily, not recognized for its true worth. The reason is that the compression or twisting violence may not have caused separation of fragments, but it has by interfering with the continuity of the bone surface, both on cortical and internal cancellous bone, cut off the precarious blood supply with local aseptic necrosis, slight absorption and ultimate appearance of a fracture line or plane seven to fourteen days later. When separation, impaction or comminution are caused at the time of fracture, roentgenologic recognition is not difficult and is seldom overlooked.

These descriptions apply mainly to the navicular, they may apply to any of the proximal row of bones, they may even apply to the distal row of bones and the condition may develop there very slowly. The lunate often suffers compressions, early unrecognized, only to undergo late aseptic necrosis with increased bone density as compared to surrounding bones seen in the roentgenogram. The day or incident of the causative trauma may be forgotten. One may be able to determine from the depth of the increased density of the bone, from the reaction of surrounding bones displayed by new bone formation or natural effort at fixation of the intercarpal joints by osseous outgrowth, or by shrinkage and collapse of the individual bone and the reaction of the wrist by pain, fixation and atrophy of soft structures just how ancient such a condition may be. The injured person may then justly be entitled to consideration for an injury forgotten or overlooked both by himself and his surgeon.

**Dislocations**—Most difficult of recognition are the *pure dislocations* which almost always involve the lunate, or the *fracture dislocations* which may involve the proximal half of the navicular and all the

lunate. These two pieces may be dislocated out of the radiocarpal joint or retained there. If retained in normal relationship with the distal articular surface of the radius, they may be accompanied by dislocation of all the rest of the hand and carpus around the two portions mentioned, either dorsally onto the top of the wrist or in volar direction. These cause great pain, swelling, stiffness and gross loss of function of the hand and may have immediate complications from nerve involvement (median). There is local hemorrhage, tearing of ligaments and finally more extensive bone necrosis from interference with circulation unless reduction is made or misplaced bone is removed to permit normal blood flow over intact avenues.

*Nomenclature.*—For many years I have urged the adoption of a specific nomenclature for these dislocations and fracture-dislocations, basing the classification on the pathological fact that they center mainly about the lunate, excluding the rare isolated dislocations. By using a specific nomenclature a word picture could be employed that would give the reader or listener or court record a definite description (and a mental picture) of the lesion. Some day the surgical world will come to it. The commonest fracture-dislocation lesion may be described as a transnavicular perilunar dorsal dislocation of the carpus which means definitely that the navicular has been broken across its body, that the proximal half of this broken bone clinging by untorn ligaments to its next door neighbor the lunate has retained normal relationship to the lunate, and that they have both remained quite decorously in the radiocarpal joint where they belonged, whereas the other carpal bones and along with them the distal portion of the fractured navicular, have been pushed dorsally by the trauma up around the lunate and navicular fragment first described, into dorsal dislocation. Result, a thickened, painful, rigid, dorsally swollen wrist, with interfered-with use of fingers and a lasting disability if not reduced and splinted for a long time. One cannot visualize these fracture-dislocations in a minute without careful repeated study. Once grasped, the many and varied fracture-dislocations can be verbally described and the listener or reader may get his mental picture at once. May surgical training finally be efficient in these lesions even as it now aims to be in other dislocations of the human skeleton.

#### DIAGNOSIS

The symptoms of carpal fracture may be very slight or lacking. The injured individual may never report for professional examination unless working under control and ordered to do so even for sprained wrists. The physical examination should be painstaking and thorough with both arms fully bared for viewing and comparison of range of motion in the wrist joint. The patient should sit with hands comfortably outstretched on a clean surface. The range of wrist motions,

*without movements of the forearm, arm or shoulders*, should be tested and compared in all directions *Local tenderness* over the proximal row of carpal bones, and then over the distal, should be searched for. The tabatiere should be tested with the patient's thumb held outstretched. The tip of the examiner's index finger or the dull end of a pencil gives an excellent means of pressure in the snuff box. Tenderness here affords suspicion of navicular injury. All swelling, over-thickness, change of range of motion in the wrist and numbness in the fingers, especially in the median distribution, should be noted and recorded. The examination should be gentle and serious, no rough manipulation should be allowed. All findings should be recorded in writing.

**Roentgenographic Diagnosis**—A roentgenogram should be made in at least two planes with the center ray directly over the radiocarpal joint. The lateral view should pose the forearm so that the shadows of the two forearm bones overlap exactly, thus giving a clear shadow study of the usual relationship between capitate, navicular and lunate in the carpus. If any other bone than the navicular is suspected of injury, additional oblique films may be required to throw the shadow of the bone suspected of injury out into clear view of profile. Don't be satisfied with any film which does not give clear definition of what may be suspected. Study the film carefully and methodically. It takes much practice to learn to read carpal films.

If a fracture plane in the navicular (most common injury) is not seen, if no dislocation of carpal elements is found, do not dismiss the patient too easily. Apply support, have the patient return in a week or ten days for another film. This must always be done if any pain or disability persists and is the best plan for all patients in the long run.

#### TREATMENT

Treatment of carpal injuries must be based on all the knowledge obtainable by the examination: a mental review of the anatomy and pathology, an inquiry into the exact cause and nature of the injury and an interpretation of the roentgenologic findings.

**Treatment of Open Wounds**—Immediate treatment after diagnosis of fracture or fracture dislocation depends on the nature of the lesion. If an *open wound* exists, it must be surgically cleansed and débrided, even if it is but skin deep. If there is a deeper laceration with joints opened into and possible nerve or blood vessel injury, the surgical care becomes a *major procedure*. It should not be attempted in any other surroundings than a properly prepared operating room. To minimize loss of tissue, unnecessary extension of wounds, loss of blood and in carrying of additional infection from unwise sponging or manipulation, and to render the repair as anatomically perfect as possible, the operation must be performed under general anesthesia and with the use of a

constrictor to ensure a bloodless field. During the repair of soft parts injury and exposure of the carpal joints and bones, a complete reduction of the fracture, its fixation if required, or a reduction of the fracture-dislocation under direct vision in an open wound may be possible. This may entail the use of strong traction by assistants on fingers or hand, counter traction on the forearm and manipulation. If instrumental aid is required to assist in open reduction of displaced fragments, this help must be of the most gentle character to avoid injury of the cartilaginous joint surface of any bones or jeopardizing further by tearing or stretching of ligaments the already interfered-with blood supply. The highest degree of preparation of an aseptic field and maintenance of aseptic technic in the operation must be obtained. After reduction the use of *sulfa drugs* may be indicated as in any open wounds or fracture according to the nature of the wound, its soiling or the surgeon's practice (see "Treatment of Open Fracture," by Kellogg Speed, Surg., Gynec. & Obst., 771 [July] 1943). Hemostasis must be secured by minimal ligation, nerves should be approximated and sutured if possible and severed tendons may be identified but not always primarily sutured, depending on the surgeon's ability and nature of the soiled wound.

**Dressing and Splinting**—The fracture or fracture-dislocation may and should be reduced. The wound is dressed, either with loose vaseline gauze pack or as a finished closed débridement of civil life. The hand, wrist and forearm are splinted in a neutral position or one demanded by the character of the fracture or fracture-dislocation to maintain reduction, with moulded plaster-of-paris strips laid on dorsal and volar surface, over adequate wound dressings. Wound dressing is performed as infrequently as possible. Each dressing may require removal of splintage in which case there must be adequate help to hold the hand and forearm in quiet position. If the wound remains aseptic, the length of time for immobilization will equal or exceed by fifty per cent that required for the healing of the ordinary closed lesion.

If there is no open wound and no fracture or fracture dislocation verified by the examination and the roentgenogram, if there is evidence of local tenderness, interference with function and complaint of pain, the hand and wrist must be immobilized on either a padded readily available splint or in a moulded plaster-of-paris splint. If the navicular is suspected of injury, the splint must extend from the metacarpophalangeal joint to just below the elbow with the hand in a straight position. The thumb should be partly abducted, fully extended and immobilized to near the tip, which may be left exposed to observe the condition of the circulation. After seven to ten days a second roentgenogram may be made through the plaster, without its removal. Developing planes of absorption or definite fracture often appears plainly through the encasing splint. If they are found, the splint, not having

been removed, does not have to be replaced, thus gaining the advantage of not moving the fragments after their first fixation in the plaster. The time elapsed since the injury was first splinted can then be added to the total number of days required for complete immobilization of the wrist.

*Fracture of the Navicular*—Fracture of the navicular, a closed and isolated injury, requires the treatment outlined in the statement just made. As soon as a diagnosis is made, immobilization in plaster of paris must be employed. From a pathologic standpoint fractures of this bone may be divided into several groups. The first classification is recent or ancient fracture. The second is whether the lesion is fracture of the tubercle, ordinary transverse fracture, usually seen near the center of the bone, comminuted fracture which may involve the whole body or simply one of the other fragments of it, proximal or distal to a transverse dividing plane through the bone. *Impacted fracture*, usually through the body, is still another type. This results in impaction of the distal fragment into the proximal along a rough irregular plane with some axial deviation of the distal portion and longitudinal splitting of the bone, which is very rare. Some transverse fractures are near the proximal end of the bone and lead to early necrosis of the proximal fragment, which is thus quite completely cut off from arterial blood supply via the small nutrient arteries and devoid of periosteal blood supply because the fragment lies almost completely free from ligamentous attachment as a loose intra articular portion. Fracture of the tubercle with adequate natural blood supply usually heals rapidly in two to four weeks, without definite immobilization but with restriction in use.

Whichever type of fracture of the body of the bone may be present, it is doubtful that local pressure or manipulation may change the angle or approximate the surfaces more evenly unless a dislocation exists. If fragments are dislocated as in fracture dislocation a manipulative effort under anesthesia to restore approximation is indicated. Any rough manipulation or undue pressure may in the simple injury add to interference with local circulation and increase the time required to restore it and to establish bony union in the bone. Consequently the hand and forearm are gently cleansed, washed with alcohol, covered with stockinet (including thumb in added small stockinet cover) and held in neutral position by a reasonably heavy plaster-of paris circular dressing from the elbow to finger bases. A sling may be used during the first few days after splinting until the plaster has hardened and any edema in the hand is absorbed. I find it advantageous to pad the ulnar styloid with a small piece of felt to avoid later developing painful pressure. A quite heavy plaster is indicated because the patient may return at once to work or other activity and not carry the forearm in a sling, but may use and move the arm and fingers where free.

thus avoiding muscular atrophy and diminished circulation in the arm as a whole. Likewise the arm thus used is subject to innumerable jolts and blows daily which may indent or break the plaster and lead to replacement long before the surgeon wishes to remove it or x-ray the bone for progress in healing.

For young vigorous adults and adolescents this dressing must remain undisturbed from six to ten weeks if it can be made to wear that long. The technic of application must be thoughtful and not haphazard. To remove, it is cut along the radial side and not along the thumb portion so that it may be slipped off, after spreading *without moving the wrist*. Immediate roentgenogram is then made to inquire into the amount of bone healing. When bony healing is quick and suitable the fracture plane as such may be obliterated. The hiatus, if any, at the site of fracture will be filled with calcified osteoid tissue. In six or ten weeks this will probably not be mature and organized into well defined bony trabeculae similar to the markings found in the body of the bone, but it may represent a clinical union on its way to maturity provided the wrist is not mistreated by overuse. If such a condition of plastic union is found, the splint may be left off, the patient advised to start use very gradually and gently and to spend time massaging finger joints, exercising hand by squeezing a suitably sized ball, but not by forcing wrist motion. I believe too hot applications or soaking of the hand and wrist exercise an untoward action on the further rebuilding and maturing of this still untrabecularized bone. Gentle steady *active* use by the patient—nothing forced or strongly manipulative—is indicated. Within a month a second roentgenogram should show further maturity of the bone, any local soreness should have disappeared and the function of the wrist and hand should be much improved. If this is *not* found and there is evidence of absorption of osteoid tissue about the fracture plane or planes, the hand and wrist should again be immobilized as before. It is far better to give an apparently too long immobilization than a too short one.

If after the removal of the plaster as outlined, the fracture appears not united, it *should at once, without movement or any manipulation* be replaced in a circular plaster-of-paris dressing to be worn an additional period of six weeks and reinvestigated by x-ray when needed. Several such plaster dressings may be needed to obtain a final bony union, proven by x-ray examination and verified by painless increasing range of motion and functional use. Don't despair too quickly—some patients require as long as ten to fourteen months of such treatment.

*Dislocation.*—If fracture-dislocation is present, is diagnosed, is understood in the displacement of its various components, the surgeon must make every effort, in the recent injury, to effect manipulative reduction. This can only be obtained under full anesthesia and with sufficient

assistance, especially in the case of manual laborers who have powerful wrists and forearms. The patient is rendered completely lax by the anesthesia. The shoulder of the affected arm is abducted to a right angle and the arm is held by an assistant in that position, grasping firmly with both hands with his feet well planted on non skidding floor, as far out of the operator's way as possible. Two assistants may be helpful—one on the opposite side of the table from the operator.

Depending on the type of dislocation, whether dorsal or volar, the operator then plans his manipulation. The first step is a *prolonged traction on the hand*, while assistants make the counter traction. Traction is maintained in the opposite direction of the dislocation, e.g., in volar dislocation of capitate and other distal row bones, the pull is slightly upward and in full extension. This must be kept up several minutes and during its course the bones may be felt sliding into place. If not successful at first, it must be repeated and can be helped by the pressure from the thumbs of an assistant against the over-riding bulging mass of bone at the dislocation site on whichever side of the wrist and hand put in a plaster dressing as described for simple fracture. Some care has to be taken of the amount of swelling, the radial pulse must be certified, the sensation and movement of the fingers checked and the condition recorded in writing as soon as anesthesia passes off. The immobilization must be gauged by the fracture more than the dislocation. Bony union must be obtained before use and movement are started, if not, one may end up with a reduced dislocation but with an ununited bone.

If manipulative reduction does not succeed under anesthesia, I believe it is best to desist for the time, to cleanse hand and wrist and encase in a sterile dressing or towel, elevating the hand on a pillow for a short time. If no bullae appear, another x-ray check may be permitted and plans for operative reduction or excision of bone or fragments planned. Don't be in too much of a hurry. Be sure the skin is clean and can be rendered aseptic for what may prove to be a longer and harder operation than thought possible.

#### ANCIENT FRACTURES

Diagnosis—Ancient fracture may be diagnosed when the patient is seen late—several weeks after injury—when there have been inadequate efforts at immobilization, or none at all, or when the injury has been called a sprain or been unrecognized or not even seen by a surgeon. The

symptoms of pain, local tenderness, restricted wrist motion, slight deformity and functional interference persist in a varying degree—some not unpleasantly, others in great intensity. There may be evidence of nerve injury, especially the median or its branches. The roentgenogram shows a spreading area of necrosis around the fracture plane, cystic absorption of much of the body of the bone (especially the navicular) or fragmentation, increased density is compared to its neighbors and sometimes new bone formation extending from adjacent bones into the joint areas about the fractured bone. Some patients appear five to ten years after fracture with marked cystic changes in the interior of the bone and increased density from the partially dead and partially healed cortex.

**Treatment**—Some ancient fractures even with the advanced pathologic changes suggested, (for detailed descriptions see monograph) may yield to *prolonged immobilization* as described. The fracture dislocations will not thus yield because much of the functional disability in them is mechanical as in an unreduced dislocation at any joint (e.g. elbow). These require well planned *excision of bone*, freeing enough space to permit some hope of recurring motion when the muscles moving the joints become reeducated. Such excision of bone should attempt to stick to old joint lines and leave intact cartilage behind. For instance in a transnavicular perilunar dislocation, ancient and unreduced the indication would be to perform a *carpectomy*—a removal of at least two of the proximal row carpal bones, namely lunate and navicular, *including the navicular fragment adherent to the distal displaced row*, and closing of the wrist with subsequent early motion and muscle training. This operation must be done without adding any injury to bones, cartilaginous surfaces of adjacent joint, nerves or tendons in the area opened. It can only be done under general anesthesia under a constrictor with suitable instruments and adequate anatomical knowledge of just what structures are being excised. I have seen outstanding surgeons make anatomical errors in these excisions. In some instances the triquetrum must also be excised along with the other two bones. The capitate then retracts back to the articular surface of the radius—a new joint motion is obtained between capitate and radius and a reasonable functional return with an almost undetectable cosmetic shortening of the carpus results. Careful planning of the amount of postoperative splinting, starting of motion and massage must be made in each case.

For the *uncomplicated ancient fracture* (as of the navicular alone) surgeons must have some operative attack when prolonged immobilization is refused or is objectionable from any standpoint. Such methods are (1) complete excision of the offending ununited bone, leaving a hiatus in its place or inserting a replica of vitallium or other metal in the defect, (2) attempts to overcome the nonunion by (a) drilling



across the fracture plane, (b) insertion of one or more small bone transplants. In some long-standing cases where the surgeon cannot be sure whether a dislocation may or may not have been a complication, a fusion of the radiocarpal joint may be the way out to relieve pain, to strengthen the joint and ultimately to increase the functional use even in the face of the permanently stiffened articulation.

Complete excision of the offending bone is frequently done for *irreducible dislocations of the lunate*, some of which may not be so ancient. The carpus seems to get along quite well without this bone. Incision is made on either dorsal or volar surface of the wrist under anesthesia and constrictor, and no structures in the wrist should be damaged. All tendons, nerves, etc., should be gently retracted. The annular ligament may be cut but must be resutured and the articular surfaces of the remaining bones may not be damaged. Tight closure and little if any splinting are required after this relatively simple excision of the lunate alone.

*Excision of the proximal row* is much more difficult, especially when one has to find and bring out the distal fragment of the fractured navicular, which clings to the distal row. It is an operation of major importance and the instructions given for all such operations must be followed.

For excision and fusion of the radiocarpal joint I prefer the approach on the ulnar side of the wrist, partial excision of the lower end of the ulna and a bone block of bone thus obtained tucked into the area to be fused followed by prolonged plaster of paris splinting.

Ancient or ununited fractures of bones which are to be retained and treated by operation may be drilled through a small opening in the tabatiere, using x ray control at the operating table to be sure of the direction and extent of insertion of the drill. Long immobilization in plaster with the same criteria for establishing union as after nonoperative treatment is required. This method I have used successfully many times, it is simple and apparently highly efficient.

*Bone Transplants*—Bone transplants have also been used to obtain union in ununited carpal bones (navicular). The transplant may be inserted in a prepared bed in the bone after dorsal exposure, or it may be inserted through drill holes made via the tabatiere. The first named method is a little grosser and may interfere further with the blood supply of the bone. Via the tabatiere the operation is delicate, but quite sure and no interference with the vascular supply need follow. Both methods require the usual prolonged immobilization. The functional results may not be forthcoming for one or two years after operation and then may not be up to the patient's expectation, yet the pain and other symptoms may be absent.

*Metallic Insertions*—Recently Captain Vaughn has made some vitalium replicas of the carpal navicular to be inserted in ancient fractures

after removal of the offending bone. Only a few instances of this substitution have as yet been done in man. It may offer a quick way out for the comminuted fracture, for the complicated fracture-dislocation and the nonunited or ancient fracture with or without cavitation in the bone. My feeling is that with the small amount of range of motion in the radiocarpal joint no analogy can be drawn with the vitalium cap in the head of the femur in the widely moved hip joint. I have examined some of the patients thus operated upon. In most there was restricted motion but not much pain.

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## TREATMENT OF RECURRENT DISLOCATION OF THE SHOULDER

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RECURRENT dislocation of the head of the humerus has been a knotty problem for the bone and joint surgeon for many years. In the days of my internship one of my chiefs in Philadelphia was operating on these cases by plication of the capsule. This, apparently, was not very successful. If an accidental surgical infection occurred the patient was relieved of the recurrent dislocation, but motion of the shoulder was very much limited. However, many of the patients were not relieved. This interested me very much, I felt that the fibrous tissue which filled in as a result of infection must have become a limiting tissue to prevent the head of the bone from getting into a position favorable to dislocation—that is, into abduction and extension of the upper arm. Abduction brings the head of the bone downward in the glenoid, extension, with the elbow pulled back of the transverse vertical plane of the body, throws the head forward. This tightens the anterior capsule and aims the head of the bone downward and forward. A blow on the elbow in this position could drive it through the capsule.

Frequently we see the shell of the greater tuberosity pulled off as one of the complications of dislocation. This occurs only in severe traumatism, and in individuals who are rather muscular. This would suggest that one of the factors that prevents the head from going downward and forward is tension on the supraspinatus and infraspinatus muscles, with some tension on the teres minor. When the shell of bone is torn off it tends to be displaced upward under the acromion between the head of the humerus and the acromion, and thus effectively forms a block for abduction of the arm.

### CAUSES OF RECURRENCE

After having used various types of operation principally the Nicola<sup>1</sup> I saw twin brothers with recurrent bilateral dislocation of the shoulder. An older brother had the same condition, and the father and father's brother had the same history. This made me wonder whether there was an anatomic weakness or muscle imbalance inherent in some indi-

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viduals which permitted the condition to occur without severe trauma. Certainly every patient who has a dislocation of the shoulder does not have recurrent dislocations.

**Tearing of the Glenoid—Bankart** explained recurrences on the basis of tearing of the anterior inferior lip of the glenoid with a gap in the capsule at the point of tearing, and certainly this is present in some cases. What the percentage is I do not know, but I have found it in a few. I have not repaired it, because I believe the capsule of the shoulder joint to be an exceedingly lax circumscribing membrane, and I do not feel that the glenoid, which is very slightly cup shaped, has much supporting function for the head of the humerus, in contradistinction to the acetabulum which is much deeper and serves as a weight bearing structure. There are no such ligaments in the shoulder capsule as are in the hip, where the Y ligament acts as a strong reinforcing band to resistance of hyperextension of the hip. The shoulder muscles are the only structures which maintain the head of the humerus in contact with the glenoid and in proper position. This is plainly evident if these muscles are paralyzed, the head of the humerus will drop away from the glenoid and may lie clear below it. That is not true of the hip, even if the muscles between the pelvis and the femur are completely paralyzed the hip will not easily dislocate, and certainly will not drop as a result of the drag of the leg. Patients who have had infantile paralysis and have a subsequent fracture of the leg must have traction applied. Never have I seen a hip pulled out of the acetabulum, but I have seen the head of the humerus pulled away from the glenoid as a result of improperly applied traction on the humerus. When the shoulder muscles are relaxed it takes very little pull to separate the head of the humerus from the glenoid, and if traction is left on for a few hours it is not difficult to create as much as half an inch of separation between the faces of the joint.

**Muscle Imbalance**—If the stated observations are correct, there must be some contributing cause to recurrent dislocation other than a tear of the capsule, tearing of the anterior lip of the glenoid, or even lack of support by the muscles. It occurred to me that it was more likely to be a lack of balance—leverage and traction of muscles to resist the downward and forward displacement of the head, rather than a lack of continuity in the glenoid or capsule.

Dr. Stack<sup>3</sup> reported twenty-two cases of operation for recurrent dislocation of the head of the humerus with about 20 per cent failures. When we came to analyze the failures we found they had occurred in individuals who had to perform constantly some motion under strain which had a tendency to throw the head of the humerus forward if not downward. In each case of recurrence following a Nicholson operation the tendon was torn loose from its attachment where it entered the head. Incidentally the entire 20 per cent of failures were

again operated on, so that we had a chance to find out what had actually happened. In some cases there was no tendon remaining, except a little ball at the upper edge of the glenoid. In others we could find no trace of the tendon of the long head of the biceps, either attached to the glenoid or to the head. In two cases we removed a gutter of bone, including the channel through which the tendon transversed the head of the humerus, and nothing was found except a few attenuated fibers of fibrous tissue. Kernwein,<sup>4</sup> in a study of tendon implantation in bone, showed that the same thing occurred in dogs, that the tendon did not exist as a tendon but degenerated into a few strands of fibrous tissue.

Again, we see a larger percentage of recurrent dislocations in epileptic than in any other class of patients, and the dislocation of a shoulder during an epileptic seizure is not at all uncommon. This would suggest that muscle imbalance and muscle leverage must have something to do with the occurrence and recurrence of downward and forward descent of the head of the humerus. It was on this basis that our investigation was undertaken.<sup>5</sup>

In the first case we thought we had solved the problem, because when the anterior capsule was exposed and the subscapularis tendon was picked up, the tendon was entirely free from the capsule instead of blending with it, as is normal, it ran as a separate and narrow tendon about  $1\frac{1}{2}$  or 2 inches long from the muscle to the lesser tuberosity of the humerus. When the arm was abducted and extended the tendon slipped up between the head of the humerus and the glenoid and lay in this space without affording any support whatsoever to the anterior capsule. In such a case, if there were a strong contracture of the pectoralis major which pulls the head of the humerus downward and forward (as is plainly seen in the typical deformity in fracture of the surgical neck of the humerus) there would be nothing to prevent the head of the humerus from stretching the anterior capsule, and, with nothing to oppose it, it would follow the line of least resistance and displace downward and forward. However, we have found only one such tendon and muscle contraction since, in a total of nine cases operated on to date. Two of these operations were performed in epileptics, and in all cases there had been dislocations from three to an unknown number of times.

#### OPERATION

The following operation was designed to meet certain conditions which I believe to exist in these recurrently dislocating shoulders. The objective is to form a cup around the anterior surface of the head of the humerus which is activated by the subscapularis muscle, and to minimize the spread between the subscapularis and the supraspinatus, infraspinatus and teres minor muscles. McLaughlin<sup>6</sup> believes that this

spread between the muscles is present in all these cases, and with this I agree. In other words, the operation brings the subscapularis tight around the head of the humerus, holding the head backward. It closes the gap, or at least narrows the space between the muscles where the attachment blends into the capsule. McLaughlin believes that the triangle at the junction of these muscles is one of the weak points. The head is held back by all the muscles attached to the greater tuberosity, and the cup of muscle and tendon and anterior capsule is tightened around the upper end of the arm to withstand the forward displacing effect of the powerful adductors (pectoralis major, latissimus dorsi and teres major) which, although attached lower down on the shaft, nevertheless have a pronounced displacing effect on the head of the humerus because their power is delivered just below it. If there is not sufficient strength in the muscles attached to the head of the humerus, or if they are not attached in the proper way, the power of the adductors is sufficient to stretch the capsule or tear it from the glenoid.

**Technic.**—An incision is made over the junction of the anterior and medial third of the deltoid, extending from the acromion downward. Muscle fibers are split and separated to expose the anterior surface of the capsule. The arm is rotated externally and the tendon of the subscapularis is picked up with a narrow smooth retractor. Observation is made of the width of this attachment and how far toward the origin of the subscapularis the blending of the tendon and capsule occurs. In one of our cases there was no blending whatever, the tendon was entirely separate from the capsule up to its attachment and was so narrow that with the arm placed in abduction and extension the tendon could be seen to slip between the head of the humerus and the coracoid. In this particular case there was no support from this muscle when the arm was in the extended abducted position.

If it is found that the tendon blends with the capsule, the tendon is pulled tight with the retractor and an incision is made, following the upper and lower borders of the subscapularis muscle from the musculotendinous junction to its attachment along the anterior lip of the bicipital groove. A chisel is then driven in on the distal side of the attachment medial to the lip of the bicipital groove, so that this groove is not weakened or made shallow. The tendinous attachment, with a wedge shaped piece of bone, is lifted, and the capsule and the tendinous attachment are reflected medially to expose the head of the humerus and the anterior edge of the glenoid (Fig. 1). Inspection can be made of the glenoid and the head of the bone through this opening, and it can be determined easily whether or not the capsule has been torn loose from the glenoid.

After inspection, the arm is brought into internal rotation and, with a suture through the attachment of the subscapularis tendon, the tendon is stretched across the bicipital groove to the greater tuberosity.

and held there while the arm is manipulated to see how much external rotation will be permitted by the subscapularis muscle. The attachment of this muscle should be moved over onto the greater tuberosity far enough really to tighten it up in 50 per cent external rotation, thus forming a roof for the long head of the biceps. When the new location for the subscapularis attachment is determined, a sharp, thin bladed chisel is driven into the greater tuberosity, with the edge of

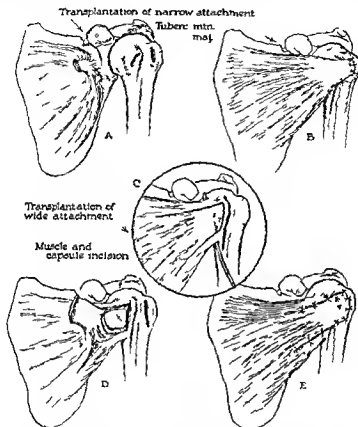


Fig 1—Transplantation of tendinous attachment A B, Narrow attachment C, D E, Wide attachment showing muscle and capsule incision

the blade held parallel to the long axis of the bone. The chisel is moved back and forth laterally to spread the cancellous bone and leave a wedge-shaped gutter, into which is forced the wedge-shaped piece of bone attached to the subscapularis tendon. The tendon is sutured to the capsule with a doubled No 00 chromic catgut suture and the sutures are repeated on both sides of the wedge so that the sides of the gutter are firmly in contact with the inserted bone. The lower border of the muscle and tendon are then tacked down by interrupted sutures

ar enough under the head of the humerus so that the muscle and capsular tendon have a firm grip around the head, with no tendency to slip up toward the coracoid and glenoid when the arm is brought into abduction and external rotation (Fig. 2).

If the operation is properly performed there will be, at its conclusion, 25 to 50 per cent limitation of external rotation. The arm

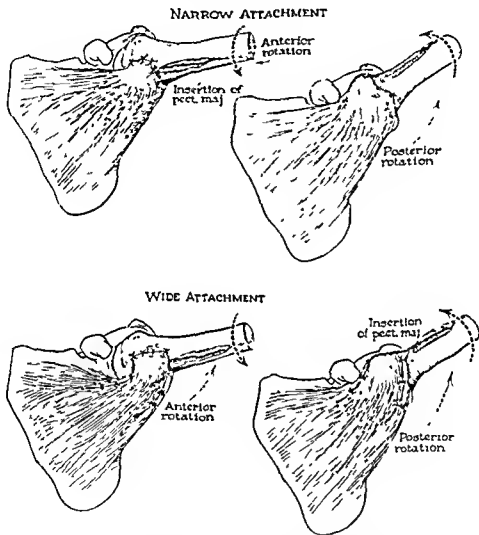


Fig. 2.—Method of suturing muscle and tendon to permit firm grip on head of humerus during abduction and external rotation.

should be moved through internal and external rotation to see whether the mechanical requirements have been achieved and that the tendon and muscle of the subscapularis wind firmly around the head of the humerus in both positions (Fig. 3). If the details have been properly carried out the procedure forms a musculotendinous cup around the head of the humerus in both external and internal rotation, which



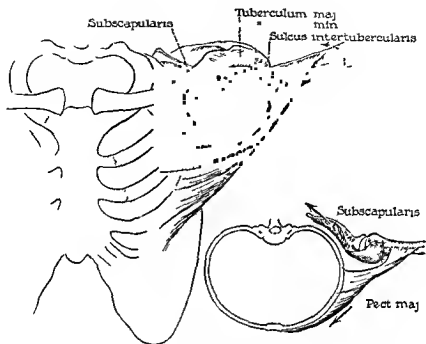


Fig 3—End result, with tendon and muscle of subscapularis wound firmly around head of humerus

resists the downward and forward displacing effect of the adductors of the humerus—a powerful group

In this group of cases the operation has served to maintain the head of the humerus in position under severe stress, when other forms of operation have failed

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## ISOLATED PARALYSIS OF THE SERRATUS ANTERIOR MUSCLE

I REMONT A. CHANDLER, M.D., I A C S \*

Isolated paralysis of the serratus anterior muscle secondary to a pathologic process in the long thoracic nerve is probably much more prevalent than the less than 200 cases reported in the literature would seem to indicate. The resulting deformity (winging of the scapula) may be quite extreme yet still remain undetected on casual examination and lead to erroneous diagnosis of arthritis, bursitis or myositis of the shoulder area followed by ineffective treatment.

Any complaint of pain or disability of the shoulder calls for a pains taking examination of the back, shoulder girdle and arm, care being taken to compare the involved side with the normal with the arm in the positions of rest, abduction, overhead extension and especially in forward flexion. Normally the scapula hugs the upper thoracic cage, rotating with various movements of the shoulder girdle and arm about fulcrum located at the sternoclavicular and the acromioclavicular articulations. The flat concave anterior surface always rests in close opposition to the convex contour of the upper thorax. In no position of the arm is the medial margin of the scapula particularly noticeable and movement is smooth and gliding in character.

In dorsal scoliosis with unilateral prominence of the ribs or in cases of tumors of the ribs or subscapular area, the lower and medial margins of the scapula become prominent but the bone as a whole remains in contact and moves over the underlying prominences. The need of a careful differential diagnosis is obvious.

The serratus anterior arises from the outer surfaces of the upper 8 ribs by a series of fleshy digitations. Those arising from the upper 4 ribs are hidden by the pectoralis minor, those arising from the lower 4 ribs interdigitate with the upper digitations of the obliquus externus abdominis. The serratus is inserted into the costal aspect of the medial border of the scapula by a linear attachment that enlarges into a small triangular area at the superior angle and into a large triangular area at the inferior angle. Only 3 ribs send digitations to the superior angle and medial border, while 5 ribs send converging digitations to the inferior angle. The reason for this distribution is apparent. The fibers

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are concentrated where they act to best advantage, which is the end of a lever. The lower digitations are required to steady or pull forwards the inferior angle when the arm is raised in front of the body; the upper digitations draw the scapula forwards thereby increasing the reach of the outstretched hand" (J C B Grant \*)

During the excursions of the scapula the rhomboids and the serratus anterior together keep the medial border applied to the chest wall.

The coracobrachialis and the long head of the biceps brachii attached to the coracoid process and the margin of the glenoid fossa are the direct antagonists of the serratus anterior muscles, rotating the scapula down and medialwards when the arm is fixed or transmitting scapular movement to the humerus when the arm is free to move to a position of anterior flexion.

Paralysis of the serratus anterior muscle permits the medial margin of the scapula to leave its position adjacent to the thoracic cage and to cause it to project posteriorly when the arm is extended forward. This deformity is especially marked when the elbow is extended. Horwitz and Tocantins call attention to the fact that winging of the scapula becomes less prominent when the elbow is flexed releasing the pull of the biceps. This indicates the prominent role of the biceps as the antagonist of the serratus anterior.

The deformity of winged scapula is accentuated by the "sucking" in of soft tissues between the medial border of the scapula and the angle of the ribs. As the scapula leaves the surface of the thorax a negative pressure develops with the necessary drawing in of the partially mobile soft tissues in the vicinity.

### ETIOLOGY

Loss of function of the serratus anterior muscle results from traumatic detachment of its insertion along the medial margin of the scapula or from paralysis. The former is very unusual and is recognized by swelling, tenderness, and at times by the palpation of a hiatus under the medial margin of the scapula.

By far the most frequent cause of "winging" is paralysis secondary to disease of the long thoracic nerve.

The long thoracic nerve arises from the posterior aspects of the rami of the fifth, sixth and seventh cervical nerves, crossing in front of the scalenus medius passing laterally and distally to enter the axilla just behind the brachial plexus and large vessels. It lies in close relation to the coracoid process and the second rib and is definitely angulated as it crosses the second rib (Horwitz and Tocantins). This position exposes it to localized trauma on depression of the shoulder girdle and on lateral flexion of the cervical spine to the opposite side. Individuals

\* *Method of Anatomy*, Baltimore, William Wood & Co., 1937, pp 23-24

with long narrow thoracic cages and low shoulder girdles would seem to be most susceptible to localized trauma

Other causative factors are toxic or infectious neuritis, pressure of shoulder straps in Trendelenburg positions and prolonged supine positions under anaesthesia

Paralysis of the serratus anterior muscle is usually accompanied by weakness of the upper portion of the trapezius and the rhomboid muscles

#### ILLUSTRATIVE CASES

CASE I—M D., a woman 25 years of age was of a very slender asthenic type and had been seen at numerous times because of various minor joint strains

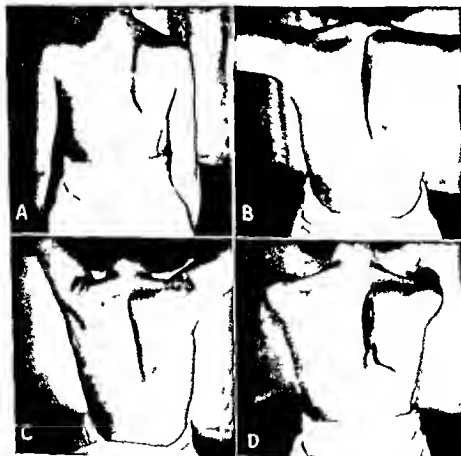


Fig 4 (Case I) —A, Prominence of medial border of scapula and loss of trapezius contour with arms at sides B Arms abducted to 90° C, Limited abduction above 90° due to failure of scapular rotation D, Marled winging when arms are extended forward

internal derangement of the knee and dislocating patella X ray of her long bones revealed a marked delay in epiphyseal closing

During the delivery of her first child she was instructed to pull on traction straps attached to the foot of the delivery table On coming out of the anaesthesia she complained of indefinite pain in her right shoulder area Her attending

obstetrician made a rather indefinite diagnosis of arthritis of the shoulder joint and prescribed diathermy and physiotherapy for five months. During this time the patient noticed increasing weakness of the right arm and inability to extend the arm forward. Examination revealed typical "winging" of the right scapula, some atrophy of the upper margin of the trapezius and total inability to extend

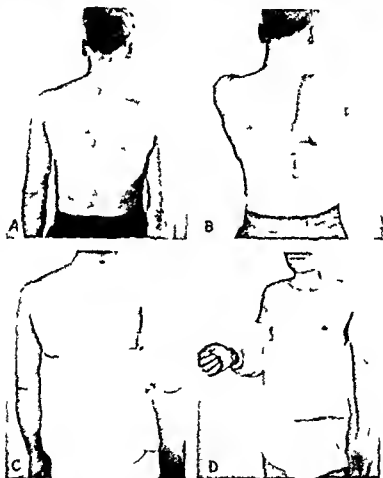


Fig 5 (Case II)—A, Right shoulder low with arms at side B, Pronounced winging when arms are extended forward C, Posterior view of cast holding shoulder girdle up and back D Anterior view of supporting cast

the arm forward (Fig 4). A diagnosis of paralysis of the serratus anterior muscle was made. Treatment by means of a supporting brace was instituted. Recovery was slow but was complete after eight months. This patient has gone through two subsequent pregnancies without any suggestion of recurrence.

This case represents a probable local trauma to the long thoracic nerve by depression of the shoulder girdle occasioned by the use of

traction straps. The error in diagnosis resulted from an inadequate examination of the shoulder area, the winging of the scapula having been overlooked because forward extension of the extended arm was not attempted.

**CASE II—A F** a man 32 years of age reported with the chief complaint of weakness of the right arm and inability to extend the arm forward. The patient stated that three weeks previously he had been playing with his small niece tossing her into the air and catching her. During one of these tosses the child fell striking the patient on the side of the neck and on the right shoulder region. The patient experienced a sudden deep pain in the shoulder area but not otherwise localized. Weakness of the arm was noted the next day. This continued until he reported for examination three weeks later. Examination revealed a healthy man excepting for a typical unilateral winging of the right scapula with some weakness of the trapezius (Fig 5). Treatment consisted in the use of a pelvic cast with elbow support. This was employed constantly for three months and then for shorter periods. Recovery has been nearly complete after eight months.

This case suggests a more direct trauma than Case I. The sudden pain and weakness indicate an abrupt stretching of the nerve.

**CASE III—M G** a man 35 years of age had as his chief complaint a weakness of the right shoulder and inability to extend the arm forward. The onset had been two weeks prior to examination. There was no history of even the

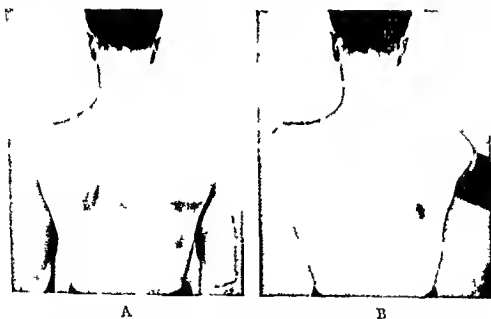


Fig. 6 (Case III)—A B Marked winging of right scapula

slightest form of trauma, no occupational factors, no history of acute infection or toxic state. Examination revealed a marked winging of the right scapula especially on forward extension of the arm (Fig 6). A pelvic cast with elbow rest was applied. This patient refused to cooperate in wearing the cast and went elsewhere. The outcome is not known.



shoulder and then is moved backward to derotate the prominent scapula. Flexion of the elbow relieves the tension of the biceps tendon which is antagonistic to the serratus anterior muscle. This brace or cast is worn continuously until recovery is complete. Local heat, gentle massage and carefully assisted movements are helpful. Active forward extension of the arm must not be permitted until recovery is complete. Even these strenuous activities should be avoided, for relapse is a definite possibility.



# FRACTURES AT THE UPPER END OF THE HUMERUS

## A Classification Based on the Etiology of the Trauma

ERNST DEHNE, M D \*

THERE are two current classifications for fractures of the head of the humerus. One, based on anatomical landmarks, describes fractures through the anatomical and the surgical neck and fractures in between the two, running through the greater and lesser tuberosity. The other, disregarding the exact anatomical site of the fractures, considers the relative position between head and shaft of the humerus and distinguishes between abduction and adduction fractures.

The weakness of the anatomical classification lies in the fact that the line of cleavage does not coincide with the anatomical landmarks. The weakness of the other classification is that the relative position of the fragments is important only in impacted fractures. In those a posterior angulation is the rule and is of clinical importance. A lateral angulation may occur, but is clinically of no significance.

The first group of cases used in this study was treated between 1931 and 1934. In 1933 and 1934 these patients were called in for a follow-up study. Duration of disability and ultimate result were recorded in each case. Over 300 records of fractures of the head of the humerus and 37 fractures of the greater tuberosity were completed.

Classification of well over 1000 x rays based on the available methods proved hopeless. A new system of classification had to be devised. The results of the original study, based on the new classification, were published in 1939. The viewpoints developed in that study were checked for efficiency and practicality from 1934 to 1944.

### ETIOLOGICAL CLASSIFICATION

The classification used in this discussion is based on etiological factors. The lines of cleavage in a fracture are determined by the direction of the traumatizing force. The majority of the fractures of the head of the humerus are due to one of three traumatic mechanisms, and the x-ray appearance of most fractures indicates which mechanism produced it.

This establishes *three main groups*. Each group is an entity with distinct clinical properties, potential complications of a specific nature,

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indications regarding x-ray examination and management, and its own prognosis. Moreover, the same mechanisms that lead to fractures may lead to dislocations as alternative injuries. The clinical properties of dislocations follow the etiological mechanisms as closely as the fractures.

Therefore in this paper the customary terms, "fracture through the anatomical neck" and "fracture through the surgical neck," are discarded. The fractures are classified according to their *etiology* as fractures caused by the lateral, dorsal or central mechanism, and referred to according to the specific morphological appearance of these three groups as three-fragment fractures, two-fragment fractures or head-splitting fractures.

#### GROUP 1. THE LATERAL FRACTURE MECHANISM

**Mechanism.**—The reader may visualize this mechanism on his own person by bringing his arm into abduction until the elbow is level with the shoulder. The elbow is then flexed 90 degrees and the forearm is

##### LATERAL MECHANISM — ANT POST VIEW OF FRACTURE

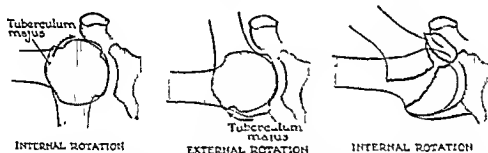


Fig. 8—The lateral mechanism. Internal rotation permits 90 degrees abduction. External rotation 180 degrees. Elevation beyond 90 degrees in internal rotation leads to injury.

pointed straight down. This puts the shoulder in maximum internal rotation. Further elevation of the elbow from this position is impossible due to the locking of the greater tuberosity against the upper rim of the glenoid fossa of the scapula (Fig. 8).

Forceful elevation of the elbow beyond this point results in one of the following injuries, depending on which structure gives way:

1. If the inferior part of the joint capsule gives way the head of the humerus pushes into the axilla, resulting in the uncomplicated *inferior dislocation*.
2. The upper rim of the glenoid fossa may drive like a chisel between head and greater tuberosity and complicate the dislocation by *fracture of the greater tuberosity*.
3. If the force of the trauma is not spent by the dislocation, the

head being solidly engaged outside the capsule may break off. This injury is a *fractured dislocation*.

4. If the capsule does not give way and the force continues, the bone structure around the greater tuberosity is under increasing pressure, the caudal part of the head of the humerus under tension. At the point where this tension exceeds the tearing point of the bony structure, the shaft disengages from the head in a curved line of cleavage (Fig. 9). The head remains in the socket and the greater tuberosity is pinched off as a separate fragment by the upper rim of the glenoid fossa. This is the *three fragment fracture*.



Fig. 9—Three fragment fracture

A series of injuries results from the impact of the rim of the glenoid fossa against the anatomical neck. These injuries will be discussed under a separate heading as *marginal injuries*.

**The Three Fragment Fracture**—The mechanism leading to this fracture (Fig. 9) is a *disengaging one*. The fragments tear rather than break. Consequently this fracture is not impacted and the fragments are in loose apposition. Any manipulation of the arm tends to disarrange the fragments, particularly abduction of the arm, which was the original direction of the trauma. The optimal position for this fracture is adduction of the arm, which reverses the direction of the trauma. The fracture is recognized by its three fragments: the head, the greater tuberosity, and the shaft.



Fig 10—Effect of airplane splint Head folds up against tuberosity.



Fig 11—Healing with head folded against tuberosity.

*X Ray Examination*—The anteroposterior view permits classification as a three fragment fracture resulting from the lateral fracture mechanism, it also reveals the full extent of the damage and displacement of fragments. A lateral view in this fracture is unnecessary because it does not afford additional information. It is contraindicated because it would necessitate abduction of the arm, which would cause pain and jeopardize the alignment of the fragments.

*Treatment of the Three Fragment Fracture*—This three fragment fracture fares best if left alone. Manipulation or the use of an airplane splint tends to shift the fragments out of alignment. The correct treat-



Fig 12—Three fragment fracture. The head is turned 90 degrees, its surface points away from the joint. The greater tuberosity is superimposed over the joint surface.

ment consists of supporting the forearm with a sling. This puts the muscles of the shoulder in a physiological position of rest and accomplishes two purposes. First, the weight of the arm acts as mild traction which in the majority of cases leads to anatomical alignment of the fragments within a week. Second, it permits early mobilization of the shoulder within a limited but painless range of motion without disturbing the position of the fragments. Thus it guarantees early restoration of function and prevents stiffness of the shoulder. Return of function in the shoulder is encouraged from the beginning by assisted motion, which is carried out daily as far as the absence of pain permits. To make use of the weight of the arm as traction the patient is encour-



Fig 13—Three fragment fracture



Fig 14—Same case as in Figure 13 on airplane splint, the head in adduction, the shaft in 90 degrees abduction

aged to be up and about during the day and in a semi sitting position on a backrest at night

**Complications**—Complications arise in three fragment fractures due to manipulation or due to the use of an airplane splint. Once the fragments lose contact they are completely out of control. The head and the tuberculum may fold up as shown in Figure 10 resulting in the condition seen in Figure 11. Or the head may rotate on the shaft so that the lesser tuberosity points toward the joint and the joint surface of the head toward the deltoid muscles (Fig. 12).

In a few cases surgical intervention becomes necessary. Figure 13 shows a three fragment fracture, the head fragment is held in maximal internal rotation by the subscapularis and in adduction by the latissimus dorsi. The greater tuberosity is displaced upward by the subscapularis. Against my advice an attempt was made to improve the position by placing the shaft on an airplane splint (Fig. 14). The head remained in

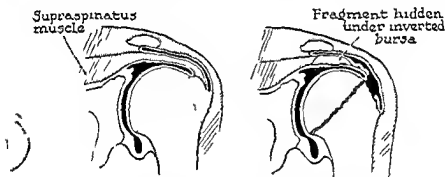


Fig. 15—Consequences of treatment on airplane splint

adduction, the greater tuberosity moved higher. Then the case was referred to me for treatment.

The surgical approach between the anterior margin of the deltoid and the pectoralis gives adequate exposure to the anterior surface of the shoulder only. If work has to be done in the area of the greater tuberosity it is necessary to turn the deltoid down. In this particular case I used the Lexer approach, dissecting the deltoid from its distal attachment and turning it upward. The exposure was most satisfactory. It was easy to line up the head fragment with the shaft by inserting a blunt hook around the subscapularis attachment at the lesser tuberosity and pulling the head into position. Head and shaft fragments were held in position by a horizontal wire sling. But the whereabouts of the greater tuberosity was a puzzle. The fragment seemed large enough in the x ray, but I could not see it in the joint. In retracting upward it had inverted the subdeltoid bursa and was completely hidden from sight (Fig. 15). To attach the greater tuberosity it is necessary to go

far down on the shaft to have solid cortical bone for the anchorage. This was done by using a vertical wire sling (Fig. 16).

This operation was done three weeks after the injury. Motion was started immediately and full return of function obtained.



Fig 16—Same case as in Figures 13 to 15. Wired, healed, recovered with full function.

#### GROUP II. THE DORSAL MECHANISM

**Mechanism.**—The instinctive reaction in a fall backward is to stretch out the arm and break the fall. This may lead either to fracture of the head of the humerus or to dislocation of the shoulder.

This traumatic mechanism has two component forces. One force pushes in a straight line along the shaft from the elbow toward the shoulder. The other force has a twisting effect similar in nature to the one in the lateral mechanism. The maximum dorsal elevation of the arm is reached when the arm locks against the spine of the scapula where it merges into the acromion. Further forceful dorsal elevation causes *fracture* at that point, leaving the head in the joint and angulating the shaft upward, or it pushes the head through the joint capsule dissecting the subscapularis off its attachment to the scapula, resulting in the *anterior dislocation*.

**The Two-Fragment Fracture.—Clinical Properties.**—Appearance and clinical properties of the fracture caused by the dorsal mechanism are determined by the two components of the traumatic force. The twist-



ing component produces a dorsal angulation the straight pushing force leads to impaction. This is true in the majority of cases. An exception occurs only in the rare cases of complete loss of contact between head and shaft.

The outstanding characteristics of this fracture are (1) Its appearance. It consists of two fragments which easily distinguishes it from the three fragment fracture resulting from the lateral mechanism (Figs 17 and 18). (2) The posterior angulation. (3) The impaction.

*Indications for X ray Examination*—If the anteroposterior view shows a fracture with three fragments no lateral x ray should be taken. The lateral view would give no further information and elevation of



Fig. 17 Two fragment fracture Uncharacteristic anteroposterior view Adduction deformity

the arm to take the lateral view would be painful and jeopardize the position of the fragments.

If the anteroposterior view shows two fragments a lateral view must be taken to determine the degree of posterior angulation. The appearance of the lateral x ray determines the treatment of the fracture. Due to the impaction of the fragments which permits elevation of the arm without pain and without disturbing the position of the fragments the lateral x ray can be taken with impunity.

*Treatment*—Strongly impacted and angulated fractures are reduced by manipulation under anesthesia. One hand fixates the shoulder with a firm grip while the other hand reverses the direction of the trauma

by bringing the elbow forward. Lesser degrees of impaction and angulation straighten out spontaneously under the influence of the weight of the arm carried in a sling or a hanging cast. Fractures with complete loss of contact between head and shaft are best reduced by traction under anesthesia. After reduction they are either held in a sling or in a hanging cast.

**The Recurrent Dislocation.**—The dislocation resulting from the lateral trauma does not tend to recur. Its potential complications are fracture of the greater tuberosity or injury of the axillary nerve.

The dislocation following the dorsal trauma has a great tendency to recur for two reasons. The minor reason lies in the fact that the

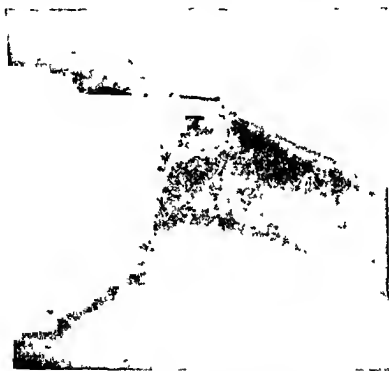


Fig 18—Two-fragment fracture The lateral characteristic view, 50 degree posterior angulation and impaction

motion of the posterior trauma is frequently repeated in everyday life. Dislocations may recur when the patient struggles into the sleeve of a heavy coat, or even when the arm falls over the edge of the bed while he is sleeping.

But the major reason is found in the *pathology of the joint* (Bankart) and its surrounding structures (Magnuson). In confirmation of this, I found the following conditions in every shoulder explored between 1938 and 1944:

1. The *Imbus glenoidalis* had torn loose from its attachment to the anterior circumference of the joint and remained loose in every case

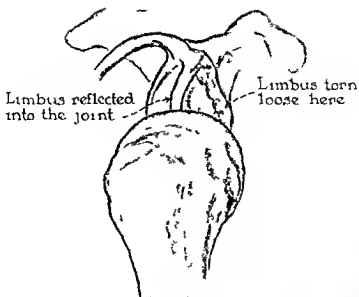


Fig 19—Bucket handle injury of labrus—an obstacle to reduction of dislocation



Fig 20—Fracture of anterior rim of glenoid Small typical defect above lesser tuberosity

opened. In one epileptic patient a dislocation had been permitted to persist for four months. The shoulder could be reduced by traction and manipulation, but would not stay in place. When it was opened the cause was found in the position of the limbus. The anterior half had torn loose and was dislocated into the posterior section of the joint, giving an appearance very similar to a bucket-handle injury of the meniscus (Fig. 19).

2. *The anterior rim of the glenoid fossa* is found bevelled off rough and denuded of cartilage. In some cases the rim is fractured (Fig. 20)



Fig. 21—A screw and washer are used to reattach the anterior capsule and the limbus to the glenoid. Note the typical defect.

3. *A false joint cavity* is found between the anterior surface of the scapula and the subscapularis. This cavity forms as the head of the humerus tears the muscle loose from its attachment. It was found in every case. The cavity either communicates with the joint or is separated only by weak adhesions.

These changes deprive the shoulder of both its structural protection against recurrent dislocation (the anterior part of the limbus, the anterior rim of the glenoid fossa and the anterior attachment of the capsule) and its physiological protection (the function of the subscapularis). The subscapularis is deprived of an essential part of its attachment; it is thinned out and relaxed.

*Treatment.*—The Bankart procedure, published in 1938, is the first

etiological approach to the problem of the dislocated shoulder. But the repair of the structural changes seemed incomplete without the correction of the second etiological factor by Magnuson's transplantation of the capsule from the lesser tuberosity to the

tion

Another minor modification of the Bankart procedure was found advantageous. Suturing the limbus to the glenoid fossa using holes drilled through the bone is technically very tedious and mechanically not too satisfactory because the sutures tend to cut through the cancellous bone. It was found both technically easier and mechanically sounder to attach limbus and capsule to the bone by using a screw and washer placed obliquely through the neck of the scapula (Fig. 21).

#### FURTHER INJURIES RESULTING FROM THE LATERAL AND THE DORSAL MECHANISMS

According to their etiology the fractured dislocations and the margin fractures have been discussed under Groups I and II. They are

particularly violent injuries. Fractures may occur in anterior or posterior dislocation. The dislocation is the primary injury, the fracture the secondary complication. The morphology of the fractures is not uniform. Prognosis depends largely on the size of the head fragment. A large head fragment gives a brighter outlook, a broken-up head a poor one.

The results obtained in the seventeen cases of my initial series (1932-34) were as follows:

Two cases were treated by *closed reduction*. The patients returned to their occupations in two and four months and eventually had full recovery of function.

Five cases were treated by *open reduction*. In three of these anatomical reduction was obtained and the functional result was excellent but short of complete recovery. The duration of disability was two, five and nine months. The results in the other two cases were poor. Injury of the brachial plexus accounted for one, inadequate anatomical reduction for the other.

Eight cases were treated by *surgical removal of the head*, either because the patients were not considered good risks for more radical

and three and a half months. The remaining cases were anterior and posterior dislocations. The removal of the heads required more surgery. These patients had painless shoulders with limited range of motion within periods of from five to nineteen months.

Two patients had *no therapy*. They had painful shoulders and both died within eighteen months of the injury.

Eight years later my associate, Dr. R. T. McElvenny, demonstrated to me his skillful application of closed methods. McElvenny was able to obtain anatomical reduction and complete functional recovery in three out of four cases. These results were obtained by the following



Fig. 22.—Fracture-dislocation. (Courtesy Dr. R. T. McElvenny.)

technic. The shaft is lined up with the head under anesthesia and impacted into the head. Then gentle traction is applied on the arm by means of the Soutter apparatus. The traction is slowly increased to about 35 pounds. After five minutes the traction is released and the maneuver is repeated after a brief rest until the head slips into the joint (Figs. 22 and 23).

Analysis of these results leads to the following conclusions:

1. The result depends on three factors: the condition of the head fragment, the general condition of the patient and the skill of the surgeon.
2. Anatomical reduction only, preferably by closed method, leads to full recovery.



Fig 23 Same patient as in Figure 22 after reduction Recovered with full function of shoulder (Courtesy Dr R T McElvenny)



Fig 24—Fracture of lower lip of glenoid

3. Surgical removal of the head fragments is a poor compromise solution. It is preferable only to inadequate surgical reduction or no therapy at all.

**Marginal Injuries.**—Marginal injuries also occur with both the lateral and the dorsal mechanisms. *Fractures of the greater and the lesser tuberosity and of the inferior rim of the glenoid fossa* are due to the lateral mechanism, the typical defect (Hermodsson) and the fracture of the anterior rim of the glenoid to the dorsal mechanism.

**Fracture of the Greater Tuberosity.**—Fracture of the greater tuberosity occurs as an independent injury or associated with the inferior dislocation. In either case it may be complicated by injury of the



Fig. 25.—Fracture of lesser tuberosity.

*axillary nerve.* This complication is recognized by weakness of the deltoid and an area of anesthesia at the distal attachment of the deltoid. The lesion was found in five cases, all of which recovered without surgical intervention. But apart from that complication, the recovery period is out of proportion to the extent of the injury.

Thirty-seven cases were analyzed in an attempt to coordinate clinical findings and prognosis. I found that the presence or absence of a dislocation does not affect the prognosis. Large single fragments and comminuted fractures in which the center of the injury is about three fourths of an inch below the anatomical neck had an average duration of disability of fourteen weeks. Comminuted fractures extending 3 to



4 mm on each side of the anatomical neck had an average duration of disability of thirty two weeks. Injuries complicated by a fracture of the lower rim of the glenoid fossa (Fig 24) were disabled for over a year.

The prognosis in fractures of the greater tuberosity is much more guarded than in uncomplicated fractures of the head of the humerus. It is therefore suggested that these injuries should be treated in bed by early mobilization with suspension traction.



Fig 26—Typical defect

*Fracture of the Lesser Tuberosity*—Fracture of the lesser tuberosity is rare. The case shown in Figure 25 recovered full function in sixteen weeks.

*The Typical Defect* (Figs 20, 21 and 26) and *Fracture of the Anterior Rim of the Glenoid* (Fig 20) are complications of the anterior dislocation. The typical defect is not associated with any pain or limitation of motion.

### GROUP III THE CENTRAL MECHANISM

*Mechanism*—The head is driven straight against the glenoid fossa. Either the head or the glenoid fossa may be injured.

*Injury of the Glenoid Fossa*—Injury of the glenoid fossa is rare. It occurs in younger people with strong bone (Fig 27) and heals without specific therapy and with complete return of function.

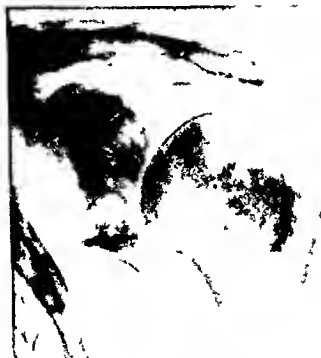


Fig 27—Split fracture of glenoid



Fig 28—Split fracture of head

**The Headsplitting Fracture**—The appearance of the injury to the head is the result of the anatomical disproportion between the size of the head and the glenoid fossa. The short horizontal diameter of the glenoid fossa contacts only a small sector of the head of the humerus. The head is split into contact and noncontact sectors and the contact sector is driven against the shaft while the relation of the noncontact sectors to the shaft remains more or less normal (Fig. 28).

The head is frequently broken up into many more fragments than can be seen in the x ray. Such extensive fragmentation leads to deform



Fig. 29—Resorption of head due to fragmentation

ity of the head due to resorption of bone and destruction of cartilage (Fig. 29). This type of fracture occurs in very old people with considerable atrophy of the bone.

**Treatment**—Return of function is incomplete. Painless motion sufficient to permit feeding or brushing the hair in women can be obtained in most cases by use of early mobilization and suspension traction of the arm and forearm.

## SUMMARY

Mechanism	Injury	X ray View	Clinical Properties	Marginal Injuries
Lateral	Inferior dislocation	Anteroposterior	Does not tend to recur	Fracture of greater tuberosity Fracture of inferior lip of glenoid
	Three fragment fracture	Anteroposterior revealing Lateral contrast indicated	Fragments in loose apposition	
Dorsal	Anterior dislocation	Lateral	Tends to recur	Fear of anterior glenoid limbus Fracture of anterior rim of glenoid Typical defect
	Two-fragment fracture	Lateral view reveals extent	Fragments impacted	
Central	Head splitting fracture	Anteroposterior	Results in deformity of head	

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## THE TREATMENT OF FRACTURES OF BOTH BONES OF THE FOREARM

EDWARD L. COMPERE, M.D., F.A.C.S.\*

No other fracture in the human body is technically more difficult to reduce and heal in good position with satisfactory function than that of both bones of the forearm. Fractures of the ulna and the radius can not be intelligently or successfully treated without knowledge of the anatomy of the bones and the muscles of the forearm and their normal function.

### ANATOMY OF FOREARM

The ulna is important in movement and in stability of the elbow. The radius makes its chief contributions through supporting, and making possible motions and dexterity of, the hand. In rotary movement the ulna is fixed while the radius rotates around it. These two bones are joined by an interosseus membrane, the fibers of which pass almost transversely but in a slightly upward direction from the ulna to the radius. In most both-bone fractures the ulna is pulled toward the radius.

**Muscles**—The muscles which are of importance from the standpoint of changing the position of the bone fragments following fracture are

- 1 The *pronator teres* which has its origin above the elbow and inserts at about the middle of the radius.
- 2 The *supinator brevis* passes from the ulna to the radius in the upper third.
- 3 The *pronator quadratus* is located in the distal third and its fibers pass almost transversely from ulna to radius.
- 4 The *biceps brachii* inserts in the upper third of the radius and serves as a pronator of the forearm and hand.
- 5 Two other muscles, the *supinator longus* and the *brachioradialis*, are of lesser importance in producing deformity following fracture.

Recovery of dexterity and strength of the forearm and hand following fracture of both the radius and the ulna is contingent upon the preservation of the interosseus space and of the function of pronation and supination, as well as healing of the fractures.

### TYPES OF FRACTURE

Fractures of both bones of the forearm may result from

- 1 A direct blow against the forearm

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## TREATMENT OF FRACTURES OF BOTH BONES OF FOREARM

- 2 A fall on the outstretched hand
- 3 A fall with the arm twisted beneath the body
- 4 Catching the hand or arm in belts rollers or wheels of power driven machines

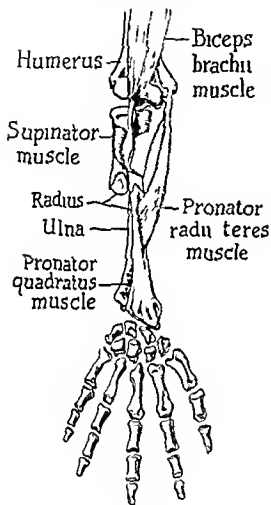


Fig 30

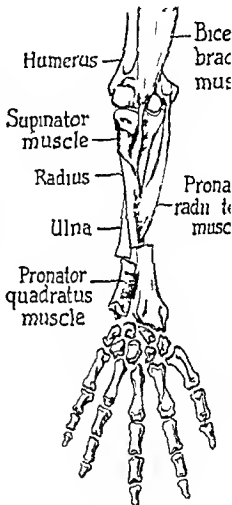


Fig 31

Fig 30—Fracture of both bones of the forearm proximal to the insertion of the pronator teres muscle. The distal fragments and the hand are in a position of complete pronation.

Fig 31—Fracture of both bones of the forearm in the distal third. Proximal fragments are in a position of midpronation-supination. Distal fragments are completely pronated by the pronator quadratus muscle.

The nature of the deformity which results from an injury of this type depends upon whether the bones are fractured at a level proximal to the insertion of the pronator teres muscle or distal to this insertion.

(A) When the fracture occurs *proximal* to the insertion of the pronator teres, the action of this powerful muscle is lost in the proximal fragments are concerned. These fragments then assume

a position of complete supination while the distal fragments are strongly pronated. In this position of pronation the radius lies obliquely across the ulna (Fig 30)

(B) When the fracture occurs *distal* to the insertion of the pronator teres, the supinators approximately balance the pull of the pronators on the proximal fragments, which are held in a position about half way between supination and pronation while the distal fragments again are strongly pronated by the unopposed action of the pronator quadratus muscle. The fracture ends of the ulna may be drawn toward the radius (Fig 31)

If the fracture is *oblique*, or if displaced even though it is transverse there will be shortening due to overlapping. *Angulation*, when it does occur, is usually posteriorward and is more common in the ulna than in the radius

#### TREATMENT

In the treatment of fractures of both bones of the forearm the following considerations are of importance

- 1 Restoration of length
- 2 Accurate apposition of fracture surfaces
- 3 Correction of alignment
- 4 Wide separation between the radius and the ulna at the site of fracture
- 5 Complete immobilization
  - (a) with the elbow flexed 90 degrees
  - (b) by means of anterior and posterior plaster splints
  - (c) by extending plaster splints to the metacarpophalangeal joints and well above the elbow
  - (d) with the forearm completely supinated for fractures above insertion of the pronator radii teres, and in midsupination pronation for fractures distal to insertion of pronator radii teres (Fig 32)

6 *Oblique fractures* may be treated by continuous traction, open reduction and plating, or skeletal pins such as the Roger Anderson, Stader or Haynes types (Fig 33)

7 *Recent compound fractures* should be debrided, cleansed thoroughly and closed without drainage. Use metal plate fixation if fracture fragments cannot be engaged end to end and thus held securely in position

8 *Old ununited fractures* require the osteogenetic stimulus of an autogenous bone graft which may be held securely in contact with both fracture fragments by means of a metal plate with the screws passing through the graft and both cortices of the respective forearm bone. Open reduction and grafting of the radius alone is usually sufficient. With the radius fixed it is possible in most cases to obtain a closed reduction and union of the ulna

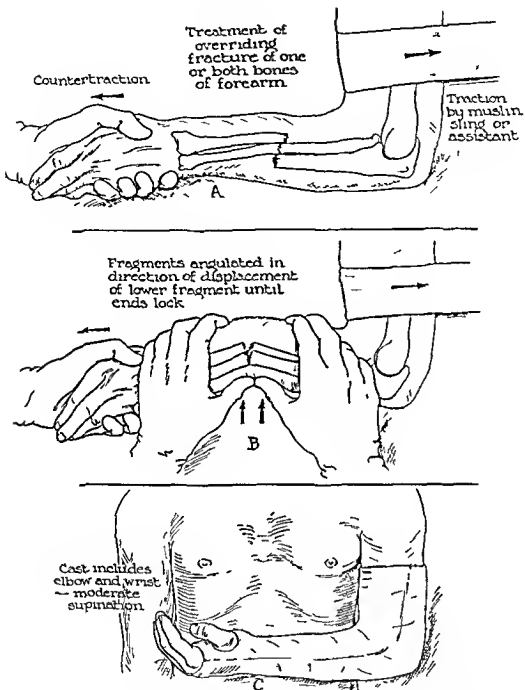


Fig 32—Manipulative reduction of a transverse fracture of both bones of the forearm. This fracture was approximately at the site of insertion of the pronator teres muscle. The hand and forearm are held by the cast in the position of supination. (From 'Pictorial Handbook of Fracture Treatment' by Compere and Banks Year Book Publishers.)

9 Old infected ununited fractures of both bones of the forearm should be treated by removal of sequestra and other necrotic tissue. Frost the wound with sulfanilamide, pack loosely with petrolatum.



a position of complete supination while the distal fragments are strongly pronated. In this position of pronation the radius lies obliquely across the ulna (Fig 30)

(B) When the fracture occurs *distal* to the insertion of the pronator teres the supinators approximately balance the pull of the pronators on the proximal fragments which are held in a position about half way between supination and pronation while the distal fragments again are strongly pronated by the unopposed action of the pronator quadratus muscle. The fracture ends of the ulna may be drawn toward the radius (Fig 31)

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**Case I—Greenstick Fracture of Both Bones of the Forearm**

H T., a girl aged 12 years, was admitted to my service at Children's Memorial Hospital on July 4, 1944. Shortly before being brought to the hospital she had tripped and fallen and tried to arrest the fall by the outstretched right hand.

Examination revealed angulation of the bones of the forearm. X-rays (Fig 34) confirmed the clinical impression of a greenstick fracture. Treatment was by means of careful molding to correct angulation without displacing the fragments. A position of 90 degrees flexion of the elbow and supination of the hand



Fig 34 (H T, Case I)—Greenstick fracture

was maintained by a plaster cast. This fracture was united after four weeks' immobilization. A short forearm molded splint was worn for an additional period of three weeks, and the patient was discharged as cured.

*Comment*—Fractures of the bones of the forearm in children are often of the greenstick type. Care must be taken to prevent making the fractures complete with displacement of the fragments.

**Case II—Simple Fracture of Both Bones of the Forearm**

D F., a boy aged 17 years, was examined by me on August 9, 1943. He had suffered a fracture of both bones of the left forearm two weeks before coming to my office. The fracture, although complete, did not result in displacement of the fragments. He had been treated efficiently by molded plaster splints applied by a doctor who lived near the summer camp which he was attending at the time of the injury.

Roentgenograms which had been made immediately after applying a snugly

fitted arm cast showed good position. Roentgenograms made in my office two weeks after this original cast had been applied showed good end to-end position but moderate angulation (Fig 35). This fracture was just proximal to the middle third and hence was above the insertion of the pronator radii teres muscle. Rotation had not been completely corrected at the time of applying the first cast. This cast was removed and a new cast was applied with the arm held in a position of complete supination. In spite of our efforts to prevent it, a slight



35 (D F Case II) —Simple complete fracture of both bones of the forearm note posterior angulation of ulna

posterior angulation of the ulna persisted. This fracture was slow in healing but interval roentgenograms showed that union was occurring. All splints were discarded on November 2, 1943—three months and a few days after the original injury.

*Comment*—Watson-Jones and other orthopedic and fracture surgeons have emphasized the fact that no time limit should be set for the immobilization of fractures of both bones of the forearm. The surgeon must use good judgment and be guided by roentgenograms in determining when to discontinue splinting. The tendency for posterior angulation of one or both bones of the forearm must be anticipated and efforts made to avoid this deformity.

#### Case III.—Compound Fracture of Both Bones of the Forearm in a Child

C. P., a lad 10 years of age, fell from one of the statues in Lincoln Park. He was seen almost immediately by a local physician who found an open wound

which extended to the bones. Sulfanilamide powder and a dry sterile dressing were applied. The wrist was supported in an anterior posterior molded plaster splint and he was sent to the hospital to be admitted on my service. The patient was taken to the operating room and under general anesthesia the forearm was thoroughly cleansed with soap and water and painted with phemerol. No iodine or other strong antiseptic was used. The wound was carefully debrided, removing an elliptical piece of skin from about the laceration, which measured 1 centimeter in length, running transversely about 2 inches above the wrist joint. After debriding, the wound was thoroughly irrigated with normal saline solution.

Portable x rays which had been obtained shortly after admission to the hospital were now brought into the operating room. These showed a transverse fracture of the radius and ulna with displacement of the distal fragment of the radius. It was immediately observed that the pronator quadratus muscle was holding the distal fragment in a position of pronation and the distal portion of the ulna had been pulled over against the radius.

All of the fracture ends were freed and accurately reduced. A satisfactory alignment was obtained. Sulfanilamide crystals were sprinkled into the wound and the incision was closed without drainage.

A plaster cast was applied to maintain a position of 90 degrees flexion of the elbow while the forearm was held about half way between supination and pronation. Care was taken to leave the fingers, including the metacarpophalangeal joints of the hand, entirely free.

Each day during the postoperative convalescence the patient was urged to exercise and use the hand as much as possible. Two months from the date of this injury the fracture was solidly united and the patient had normal range of motion in fingers, wrist and elbow.

*Comment*—This patient was fortunate to receive excellent first aid care. Subsequently by debriding and cleansing the wound primary healing was obtained. Thus a compound injury was transformed into a simple fracture. Recovery was rapid and complete.

#### Case IV—Fracture of Both Bones of the Right Forearm Treated by Open Reduction and Metal Plate

H. K., a man of 28 years was admitted to my service at the Wesley Memorial Hospital for emergency care on September 15, 1943. He was seen almost immediately by my associate Dr. William Schnute. History of an injury to the right arm which had occurred about two hours earlier was obtained. His arm had been caught in a motor driven belt and dragged between the pulleys. There was immediate pain, swelling and deformity of the lower third of the right forearm. Although there were some superficial abrasions there was no complete break through the protective covering of the skin. Roentgenograms revealed complete fracture of both bones of the forearm about 4 inches above the right wrist with displacement of all fragments.

This fracture was accurately reduced under general anesthesia. A cast which extended from near the shoulder to and including the hand, but permitting free movement of the fingers was applied. Roentgenograms which were made immediately after immobilization showed that the bones were well aligned and the fracture surfaces in good apposition. Roentgenograms one week later showed that the fragments had again become displaced (Fig. 36). This was in spite of the fact that the cast used had very little padding.

On September 29, 1943 (fourteen days after the original injury and attempt at closed reduction), an open operation was carried out. It was determined to

operate on the radius only, as it was thought that after accurately reducing and maintaining this fracture it would be possible to obtain a reduction of the ulna by closed methods. The fracture of the radius was exposed by means of a posterolateral incision. The sheath of some of the muscles was found to be interposed between the fragments. The fracture was accurately reduced but because of obliqueness of the fracture surfaces, position could not be maintained by locking the fragments. A screw was inserted from the lateral surface to secure the oblique fragments. A four screw stainless steel plate was applied anteriorly and fixed

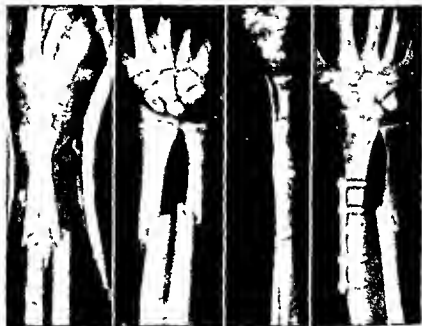


Fig 36 (H K, Case IV)—Oblique fracture of both bones of right forearm treated by open reduction and metal plate

securely in position with the screws passing through both cortices (Fig 36). The arm was then placed in a cast which extended from just below the axilla to the metacarpophalangeal joint of the hand with the forearm in a position of mid supination/pronation. The fractures healed satisfactorily, and on December 28, 1943, union was considered to be complete. The metal plate was removed on April 5, 1944.

*Comment*—Oblique fractures of both bones of the forearm cannot be held satisfactorily by simple plaster or splints. These must be treated either by continuous traction on the distal fragments, by skeletal pins incorporated in a cast or by open reduction and metal plate fixation.

#### Case V.—Fracture of Both Bones of the Forearm with Nonunion

This fracture occurred on April 20, 1940, when the patient, a boy aged 17 years, fell from a bicycle. Attempts at closed reduction by his family physician

were not successful. When I examined the patient, the fragments of both the radius and ulna were markedly displaced.

An open reduction was carried out on both the radius and the ulna. Accurate reduction was obtained. A bone graft was cut with the motor saw from the proximal fragment of each of the forearm bones. These grafts were applied *inlay* across the fracture lines. Thin *onlay* grafts were also used to bridge the fractures. Immobilization was maintained by means of a cast which extended from the shoulder to the metacarpal joint. The patient was discharged from the hospital six days after the operation. Union occurred within less than six weeks. All splinting was discontinued eight weeks after the operation. Six months after the injury the family physician reported that this patient had completely normal function and strength in the arm.

*Comment*—Nonunion of fractures of both bones of the forearm may be treated successfully by means of open reduction, autogenous bone graft and adequate immobilization. If the fractures are oblique or end-to-end position cannot be maintained by locking of the fragments, a metal plate should be used in addition to the bone grafts.

#### Case VI—Postoperative Infection of a Simple Fracture of Both Bones of the Forearm

M. W., a woman aged 21 years, was first examined by me on February 18, 1943. She had suffered a fracture of both bones of her right forearm on December 31, 1942, when her hand was caught in a soft drink bottling machine. This was not a compound fracture. A cast was applied but reduction of the fracture was not obtained. Two different operations were then undertaken by surgeons who were not trained for bone and joint surgery. The first operation failed to obtain or maintain reduction. Following a second operation in which a small inadequate metal plate was applied, the wound became infected and there was a severe sepsis.

When I examined this young woman the arm was swollen, pus was oozing from between the stitches of the wound and the forearm was inadequately immobilized by a single short aluminum splint (Fig. 37). The forearm was pronated when it should have been supinated. There was moderate swelling of the hand and fingers and this patient was unable or unwilling because of pain to flex the fingers or move the hand at the wrist. Fortunately sensation was unimpaired.

This patient was admitted to my service in the Wesley Memorial Hospital on February 19, 1943. The wounds were opened widely, frosted with sulfanilamide and loosely packed with petrolatum gauze. A cast which extended from just proximal to the metacarpophalangeal joint of the hand to well above the elbow was applied with hand and forearm in a position of supination and the elbow flexed 90 degrees. The metal plates were left in position. Although they were not giving rigid support, these plates did help to keep the fracture fragments from displacing.

On March 28, 1943, both metal plates were removed and the rusty necrotic exudate was everted from the screw holes. Healing of the wound progressed. The plates were removed on June 14, 1943. At this time there was still movement between the fragments. The plates were discontinued on August 16, 1943, and the patient was advised that she could begin actively to use this hand. At this time I was of the opinion that a bone graft operation would be necessary at a later date in order to repair the defect in the radius. Fortunately, periosteal new bone be-

gan to form and by December 16 1943 there was definite bone union between the two fragments of the radius. On January 14 1944 the deep adherent scars were excised. During the latter months in which this patient was under observation she received physical therapy two or three times each week. She regained excellent function of the hand and forearm and is now using this arm almost as well as before it was injured.



Fig 37 (M. W. Case VI) Simple fracture of both bones of the forearm complicated by osteomyelitis following attempts at open reduction.

*Comment*—The lessons to be learned here are multiple.

- 1 Surgeons not trained in the disciplines of bone and joint surgery will be wiser not to attempt open reduction and plating of fractures.
- 2 A most careful aseptic technic is imperative for bone and joint surgery.
- 3 A short forearm splint is never adequate to immobilize fractures of the shaft of the radius and ulna.
- 4 The forearm should be maintained in a position of supination or midpronation-supination.
- 5 The natural forces of repair may be greater than the surgeon anticipates. Union of the radius in this instance after the soft tissue wound had healed bridged a wide defect between the two bone fragments. This eliminated the hazard and uncertainty of a bone graft operation which I had thought would be necessary.

## FRACTURES OF THE ELBOW IN CHILDREN

JOHN J. FAHEY, M.D., F.A.C.S.\*

FRACTURES about the elbow constitute one of the most frequent sites of involvement in children. In a study of over 2000 fractures in children, Beckman and Sullivan found 13 per cent involving the lower end of the humerus and observed that it was the second most common site of involvement, the most common being the lower third of the radius.

The frequency of each type of elbow fracture in 100 consecutive cases in children under 14 years of age at St. Francis Hospital, Evanston, Illinois, is given in the table on the following page.

### ANATOMICAL CONSIDERATIONS

A thorough knowledge of the development of the epiphysis as to the age of appearance and time of fusion, is important in correctly interpreting the x-ray findings.

The elbow is a ginglymus type of a diarthrodial joint. The *capitellum* lies in front of the shaft and articulates with the shallow depression of the radial head. Its center of ossification appears at 2 years of age. Just above the capitellum anteriorly is the shallow *radial fossa*. The *trochlea* is the pulley shaped articular surface lying on a plane with the shaft and articulating with the sigmoid fossa of the ulna. The center of ossification appears at about 12 years of age. Above anteriorly is the *coronoid fossa* for articulation with the coronoid of the ulna in flexion. Above posteriorly the *olecranon fossa* receives the olecranon process of the ulna.

The prominent projections at each side of the lower end of the humerus are the *medial* and *lateral epicondyles*. The medial epicondyle is a separate epiphysis appearing at 5 years of age and is extra articular. The flexor pronator group of muscles arises from the anterior aspect. The common extensor group of muscles arises from the posterior aspect of the lateral epicondyle. The center of ossification for this epiphysis when present makes its appearance at the age of 12. The articular capsule attaches in a V shaped manner about the joint so that the epiphyseal line is partially intra articular and partially extra articular. The normal range of motion is from 30 to 180 degrees. In complete flexion the tip of the index finger can be placed on the shoulder at the

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## ANALYSIS OF 100 CONSECUTIVE CASES OF ELBOW FRACTURE IN CHILDREN

*Supracondylar Fracture*

Metaphyseal (adjacent to the epiphyseal line) (no displacement) 2

Fracture through the coronoid and olecranon fossa

No displacement 26

Slightly displaced 6

Displaced 22

Fracture above the fossa

No displacement 2

Displaced 2

TOTAL SUPRACONDYLAR FRACTURES 60

*Fracture of Lateral Condyle*

Metaphysis of capitellum with no displacement 6

Metaphysis of capitellum with little displacement 4

Metaphysis of capitellum with displacement 5

TOTAL LATERAL CONDYLE FRACTURES 15

*Fracture of Medial Epicondyle* 7

(Five of these were associated with dislocation of the elbow and in one it was necessary to remove the epicondyle from the joint by surgery after reduction of the dislocation)

*Fracture of Upper End of Radius*

Radial head 2

Neck

No displacement 1

Slight displacement 1

Displaced 3

TOTAL FRACTURES OF UPPER END OF RADIUS 7

*Fracture of Olecranon*

Without displacement 3

With displacement 1

TOTAL FRACTURES OF OLECRANON 4

*T Fracture* 1

Compound 1

TOTAL T FRACTURES 1

*Fracture of Coronoid* 2*Fracture of Lateral Epicondyle* (with slight displacement) 1*Fracture of Capitellar Epiphysis* (displaced forward) 1

TOTAL FRACTURES OF ELBOW 100

NOTE Seven dislocations were seen during this time five of them associated with a fracture of the medial epicondyle, and only two unassociated with a fracture

acromioclavicular joint The epicondyles and the tip of the olecranon are in a straight transverse line when the elbow is extended, and the olecranon moves downward on flexion producing a triangle

## GENERAL CONSIDERATIONS

It has been fairly well established that good function is the usual sequence of fractured elbows in children even though a satisfactory reduction might not have been accomplished Cubitus varus and valgus deformities due to improper reduction or growth arrest are not un-

common. While function in flexion and extension is usually good, limitation of the extremes of motion are not infrequent and occasionally a severe restriction of motion is seen as a result of a fractured elbow in childhood. The growth compensation factor so well demonstrated in many types of fractures seen in children often falls short in elbow fractures. Deformities and latent ulnar nerve symptoms resulting from improper reduction and growth disturbances are often embarrassing to the patient and the physician and sometimes follow what appears to be a minor displacement.

#### SUPRACONDYLAR FRACTURE

Supracondylar fractures constitute the most frequent type of fracture about the elbow in children—60 per cent in this series. A backward force such as a fall on the hand with the elbow flexed or a hyper-



Fig 38—Boy H aged 3. Supracondylar fracture through the fossa with impaction and minimal separation of capitellum.

extension force of the elbow displaces the distal fragment backward and it is held in this position by the triceps. The distal end of the proximal fragment may project into the cubital space producing pressure on nerves and vessels. The fracture line is usually transverse and extends backward and upward. The elbow is swollen and motion is limited. If the fragments are displaced the region over the posterior

surface of the humerus is concave and the points of the olecranon and epicondyles are in their normal relationship

**Treatment—Fracture with No or Only a Little Displacement**—In cases with no displacement or with only a little displacement (Fig 38), *immobilization* in flexion at a right angle with a light plaster cast from the upper arm to the metacarpophalangeal joints is advisable. The cast is removed over its anterior aspect and the extremity is supported in a sling. The cast is removed in three weeks and the arm is carried in a sling for an additional week or two. In cases with displacement (Figs 39 and 40) manual reduction is accomplished by placing the thumbs over the lower fragment posteriorly and pushing forward as the shaft is forced posteriorly with the other fingers while flexion and extension are carried out. The extremity is then immobilized as described above.



Fig 39—Girl H. Roentgenograms show supracondylar fracture with slight posterior displacement.

**Fracture with Marked Displacement**—In cases in which the distal fragment is displaced, an examination of the hand is important in order to determine if there is any nerve damage. With proper management of the fracture this condition if present usually disappears in four to ten weeks. Manual reduction is accomplished by having an assistant support the forearm. If there is medial or lateral displacement it is corrected and with the thumbs posteriorly over the distal fragment while traction is being applied it is pushed into position as the elbow is flexed as described above. To prevent displacement and rotation of the distal fragment, a light shoulder spica is applied with the arm to the side and the forearm supinated and at a right angle. The plaster is removed along the anterior aspect of the extremity to allow for subsequent swelling. The radial artery should be inspected to see that it is

not obstructed. The patient should be hospitalized for a few days, and every two hours for the first twelve hours following reduction a check should be made on pain, color, swelling, sensory change, numbness of the fingers and motion. If there is a severe disturbance in circulation, such as pain, swelling, cyanosis, disturbance of sensation with loss of the radial pulse and an impending Volkmann's contracture, the cast should be removed. Reduction of a displaced fracture may relieve the pressure. Traction on the partially extended forearm as described by Dunlop, and elevation will aid in relieving the tension. In certain cases it may be necessary to incise the fascia in order to relieve the tension. It is often difficult to reduce and to maintain reduction of the displaced type of fracture. The swelling may be so marked that manual

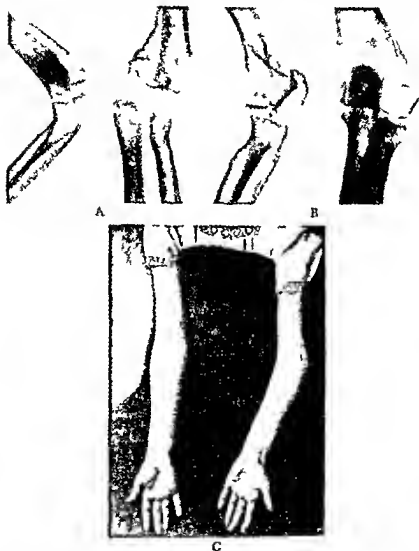


Fig 40—F M., aged 3. Roentgenograms show supracondylar fracture with posterior displacement (A) Lateral view (B) after reduction by manipulation and cast immobilization.

reduction is difficult. Cases satisfactorily reduced may slip into an unsatisfactory state while in immobilization. A high incidence of cubitus varus deformity has been reported in this type of fracture, particularly in those cases with ulnar displacement and rotation. Improper reduction and poor immobilization are responsible for many of the poor results. Cases immobilized in flexion may have what appears to be a good reduction since the deformity may disappear in flexion and become obvious only on extension.

The fracture should be checked by *x-ray* following reduction and at frequent intervals thereafter because, if the fragments should slip, as they frequently do, malposition will occur before it is detected.

CASE I.—J. V. a girl aged 5½ years fell from a swing injuring her left elbow. The deformity was reduced by her physician under general anesthesia and the postoperative x ray showed a satisfactory reduction. When seen six weeks later x ray (Fig. 41 A) showed the distal fragment displaced medially.



C

Fig. 41 (Case I)—A Roentgenograms show malunion with ulnar and posterior displacement eight weeks following fracture. B, C Roentgenograms and photograph six years later showing marked cubitus varus deformity.

and posteriorly. Six years later at the age of 11½ years there is marked varus deformity with loss of the last 20 degrees of extension (Fig. 41 B, C). Wedge supracondylar osteotomy with its base laterally was recommended at the time growth is complete.

*Use of Screw.*—In cases in which manipulation fails, traction on the partially flexed forearm and downward traction on the arm, according to the method of Dunlop, may be tried. Where the skin is in poor condition, in certain nerve injuries and in cases seen late, direct skeletal traction by means of a screw through the upper end of the ulna as described by Cubbins, Callahan and Scuderi has been found satisfactory. The bone is exposed through an incision one inch long opposite the coronoid process of the ulna. A drill hole is made through the cortex and a vitallium screw or hook screw is applied deep into the bone, after which the surrounding skin is approximated with interrupted dermal sutures. Traction is then applied in line with the humerus. Overhead traction supports the forearm at a right angle to the arm and, by adding weight and checking by x-ray, the proper amount of weight can be determined. Usually in three to four weeks the traction can be removed. Then we apply a light shoulder spica cast with the arm to the side and in supination. This remains in place for an additional two weeks when the extremity is placed in a sling and active exercises started.

CASE II—J. S., aged 8 years, sustained a supracondylar fracture of the left elbow following a fall. Satisfactory reduction was accomplished but ten days later roentgenograms showed a posterior displacement (Fig. 42, A). Because of



Fig. 42 (Case II)—A, Lateral view roentgenogram shows posterior displacement of the distal fragments ten days following a successful reduction. B, Roentgenograms twenty-two days following traction on a screw through the upper end of the ulna and just before the screw was removed and the cast applied.

the indurated swelling, closed reduction failed and a vitallium screw was inserted through the upper end of the ulna. Six pounds of traction were applied. Roentgenograms made three and a half weeks later show the displacement corrected (Fig. 42, B). The screw was removed and a posterior molded splint was

applied with a sling for two weeks at the conclusion of which the arm was placed in a sling and active motion started. Function gradually returned to normal.

**Case III—T B** a boy aged 11 years fell from a tree injuring his left elbow. On admission two hours after injury there was a lateral displacement of the elbow and marked swelling so that the bony landmarks could not be palpated.



Fig 41 (Case III) A Roentgenograms of supracondylar fracture with medial displacement B Roentgenograms fifteen months later. All of the posterior displacement was not corrected but motion is normal and there is no noticeable alteration of the carrying angle.

Figure 43 A shows a supracondylar fracture with medial displacement of the distal fragment. Closed reduction failed a stainless steel screw was inserted under local anesthesia and five pounds of traction applied with 2 pounds added a few

days later. Three and a half weeks following traction the reduction was satisfactory; the screw was removed and a cast applied for two weeks at the end of which the arm was placed in a sling and motion started. Fifteen months later (Fig. 43) motion was normal and there was no loss of the carrying angle. The anteroposterior motion was not completely corrected by the traction but, as a result of growth, this site has gradually moved farther from the joint and has not interfered with flexion.

#### LATERAL CONDYLE FRACTURE

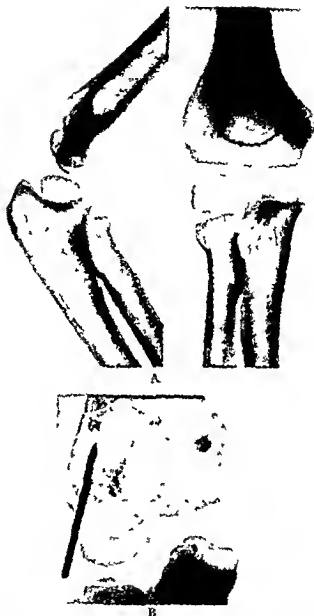
In fifteen of our cases, or 15 per cent, there was a fracture of the lateral condyle; in six of these there was no displacement, in four only slight displacement, and in five the fragment was displaced. This type



Fig 44 (Case IV).—Roentgenograms show fracture of capitellar metaphysis. There is only slight separation and conservative treatment is indicated.

of fracture is caused by a force transmitted up the radius as a fall on the hand, by an abduction force or a direct blow over the condyle. A piece of metaphysis is usually separated with the capitellar epiphysis and the epiphyseal cartilage. The fracture begins on the articular surface medial to the capitellum and passes upward and outward and may include the lateral epicondyle as well as part of the trochlea. The displaced fragment is rotated by the common extensor tendon so that





B

Fig 45 (Case V).—A, Roentgenograms show fracture through metaphysis of capitellum with tilting and downward displacement. B, Postoperative roentgenogram showing the capitellum held in position with a pin which is cut just beneath the skin so that it can be removed when healing is complete.

the articular surface faces upwards and medially, and may be rotated through an arc of 180 degrees. There is localized swelling in the region of the condyle. The carrying angle is increased, and there is hyper-

mobility and a loss of the relationship of the lateral epicondyle to the medial epicondyle and the tip of the olecranon. In cases with little or no displacement, plaster immobilization in flexion and supination with a sling for three weeks followed by a sling and active motion is sufficient.

**CASE IV.**—O. H., aged 4, fell on her elbow and complained of pain. She had moderate swelling, especially over the outer aspect of the humerus with pain on pressure, and motion was free for only 80 degrees. The roentgenogram (Fig 44) shows a fracture through the metaphyseal portion of the capitellar region with a little separation. The elbow was placed in flexion and supination and immobilized in plaster with a sling for three and a half weeks. Active motion was then carried out for two weeks with the extremity in a sling. One month later function was normal.

Where the fragment is displaced and rotated, traction with supination and pronation may be tried, attempting to manipulate the fragment into position and then flexing the elbow. While this may be satisfactory in milder cases of separation it usually fails in the well displaced case and open reduction is necessary.

**CASE V.**—H. O., aged 6 years fell on his arm causing pain and swelling of the right elbow. There was moderate swelling and motion was limited to half of normal. Pain was more marked on pressure over the condyle. The roentgenogram (Fig 45 A) shows the downward displacement of the capitellum and a tilting of the articular surface inward. Manipulation had no influence on changing the position. A posterior incision was made over the capitellum and the fracture through the capitellar metaphysis exposed. It was replaced and held in position with a pin which was cut beneath the skin so that it could be removed following healing (Fig 45 B).

Nonunion and growth arrest resulting in an increase of the carrying angle is the usual sequence following improper reduction of capitellar fractures. Many years following fracture, ulnar nerve symptoms may follow as a result of gradual stretching.

**CASE VI.**—J. Z., a man aged 26 years complained of difficulty in using his ring and little fingers on the right hand. This had first been noticed four years previously and had gradually become more marked. There was tingling and numbness of the little finger and half of the ring finger. The patient had sustained a fracture of the elbow at the age of 3. The carrying angle was increased to 35 degrees and the last 30 degrees of motion were lost. The fourth and fifth fingers were hyperextended at the metacarpophalangeal joints and flexed at the interphalangeal joints. There was atrophy of the interosseous muscles of these fingers (Fig 46 B). X rays showed a cubitus valgus deformity with an ununited fracture of the lateral condyle of the humerus (Fig 46 A). A curved incision was made over the internal epicondyle with the convexity posteriorly and the ulnar nerve was found to be hypertrophied. This nerve was removed from its bed behind the internal epicondyle and transplanted well anteriorly and held

with a small strip of fascia detached at one end from the flexor muscles and sutured so as to prevent the nerve from slipping. Numbness gradually disap-

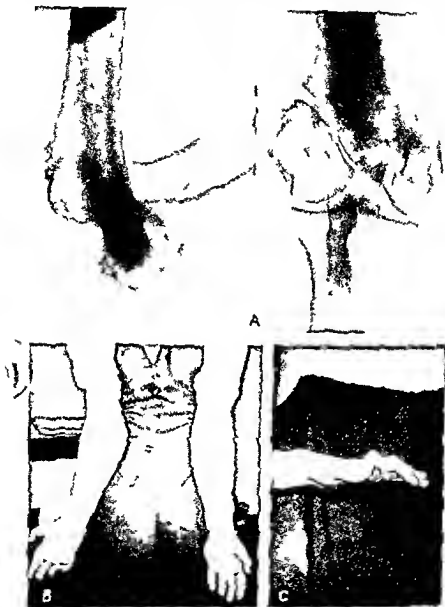


Fig. 46 (Case VI).—A Roentgenogram twenty two years after a fracture of the elbow at the age of three years. Nonunion of the capitellum. B C Photographs showing cubitus valgus deformity and deformity of ulnar nerve paralysis.

peared and the function improved during the next years. Although recovery is not complete, he is much improved.

## FRACTURE OF THE MEDIAL EPICONDYLE

Fractures involving the medial epicondyle usually follow a force which causes an abduction force of the elbow, producing pressure on the epicondyle through the flexor group of muscles or the internal lateral ligament, or by a direct force to the epicondyle itself. There is pain localized over the epicondylar region with swelling. There is weakness of pronation and flexion of the hand produces pain. If the swelling is not too great and the displacement is marked, one may be able to palpate the fragment. The region should be compared with the other side. The last few degrees of motion may be limited.



Fig 47 (Case VII) —Medial epicondyle displaced downwards. Difficult to reduce except by open operation.

If there is little or no displacement, immobilization in flexion and pronation for three weeks in a cast and sling is advisable, followed by active motion and a sling for one week.

Flexion and pronation may be tried but it usually will not accomplish reduction in cases in which the epicondyle is displaced (see Case VII), open reduction should be done and the fragment held in position with a suture or pin. Nonunion practically always follows this type of case when reduction is not accomplished. Younger children with nonunion and separation are prone to local growth disturbance, and subsequently an ulnar neuritis may develop because of a disturbance of

the bed of the ulna. The extremes of extension may be limited by blocking the olecranon process.

**CASE VII**—O. S., a boy of 8 years, fell while playing and complained of pain on the inner side of his elbow. There was swelling over the epicondylar region and the last 10 degrees of motion were painful. Roentgenograms (Fig. 47) showed downward displacement of the epicondyle. Flexion and pronation and manipulation did not accomplish reduction. Operation was refused.

If the force is severe enough, the elbow is dislocated and the epicondyle is widely separated. The epicondyle may be in good position following reduction of the elbow.

**CASE VIII**—C. Z., a girl aged 7 years, fell from a swing landing on her left elbow. There was a deformity present and the olecranon process of the ulna was displaced backwards in relation to the epicondyles and active motion was painful. Roentgenograms (Fig. 48) showed a posterior displacement of the elbow with backward displacement of the epicondyle (Fig. 48, A). The thumbs were

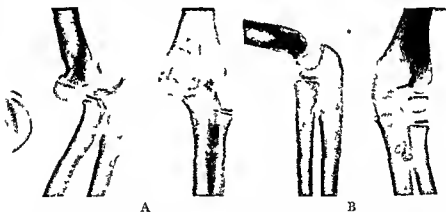


Fig. 48 (Case VIII) A, Roentgenogram shows posterior dislocation of the elbow with backward displacement of the internal epicondyle following a fall on the left elbow. B, Roentgenograms following reduction shows the epicondyle in good position.

placed over the olecranon and the hands around the front of the elbow and by pushing downwards the elbow dislocation was reduced. Roentgenograms following reduction (Fig. 48, B) show both the dislocation and the epicondyle to be in good position. A light cast was applied with the forearm at right angles. This remained on for three weeks, then a sling and active exercises were instituted.

Following reduction of the elbow the epicondyle may not be in satisfactory position and in such cases nonunion is almost sure to follow.

CASE IX—R D., a boy 12 years of age, injured his elbow while wrestling causing deformity and loss of function. There was lateral displacement of the olecranon and radius (Fig 49, A) and the epicondyle was separated. Under gas anesthesia the lateral displacement was corrected and the dislocation reduced. The epicondyle was not completely reduced. The extremity was immobilized



Fig 49 (Case IX) —A Roentgenogram shows lateral dislocation of the right elbow with separation of the internal epicondyle. B, Roentgenograms made eight weeks after reduction show nonunion of the epicondyle with some downward displacement. Normal function.

in plaster for three weeks with the forearm in pronation. Roentgenograms eight weeks later (Fig 49 B) showed nonunion and displacement. In spite of this he has a good cosmetic and functional result and considers the elbow normal. Open reduction should have been done following reduction of the elbow dislocation.

In five of seven cases fracture of the medial epicondyle was associated with a *dislocation of the elbow*. The epicondyle is occasionally pulled into the elbow when the dislocation is reduced, producing a separation between the trochlea and its articulation. Cases of successful manipulation dislodging the epicondyle from the joint have been reported but this procedure is not without danger, especially in cases where the ulnar nerve is involved and, even if reduction were accomplished, the fragment may not be satisfactorily reduced and operation would be necessary.

CASE X—J E., aged 14 years, fell on his elbow while playing basketball with resultant pain, deformity and loss of function. X rays (Fig 50) showed a posterolateral dislocation of the elbow, with the medial epicondyle separated and lying in front of the trochlear fossa. X rays made following reduction (Fig 50 B) show the epicondyle still missing from its normal position and wedged between the trochlea and its fossa separating the joint. The joint was especially tender over the epicondylar region where the defect could be palpated. There was 10 degrees increase of the carrying angle, 10 degrees of motion from a right angle and lateral instability of the joint. An incision was made over the medial

aspect of the elbow joint. The medial side of the capsule was torn and the flexor group of muscles with the internal epicondyle were removed from the joint. The bony epicondyle was then removed from its fibrous muscular attachment and these structures sutured over the defect. The extremity was immobilized in a cast for three weeks with the forearm in pronation. At the end of this time the cast was removed, the extremity placed in a sling and active motion started. This was continued for one week. Function gradually returned and the patient is without symptoms five years following operation. There is no cosmetic defect as a result of the removal of the epicondyle.



Fig 50 (Case X) —A Roentgenogram shows posterolateral dislocation of elbow with separation of the medial epicondyle. B Lateral view after reduction of the elbow shows the epicondyle wedged within the joint.

*Involvement of Ulnar Nerve*—The ulnar nerve is sometimes pulled into the joint with the epicondyle and the flexor muscle group producing partial or complete paralysis. These cases are treated by removing the fragment, nerve and soft tissue by operation and fixing or removing the fragment. In older children in whom growth is nearly complete and the fragment is small or distorted it can be removed and the fibrous muscular attachment sutured over the defect. This gives a more prompt recovery and has no cosmetic disadvantage. In younger individuals it is sutured in position so as not to interfere with growth of the epicondylar region. In cases of ulnar nerve injury, transplanting the ulnar may be done to prevent further damage and a more rapid recovery. Disturbances of growth in this fracture do not alter the carrying angle of the elbow as it is a separate epiphysis from those of the joint.

#### FRACTURES OF THE RADIAL HEAD AND NECK

In 7 per cent of our cases the upper end of the radius was involved, the radial head in 2 per cent, the neck without any significant displacement in 2 per cent, and in 3 per cent the neck was fractured and the head displaced from its articulation with the capitulum. These fractures usually result from a fall on the hand, the force being transmitted

up the forearm. In cases of fracture of the head, even where some of the fragments are considerably separated and in cases where the neck is fractured with no appreciable separation a satisfactory result with good function will follow a short period of immobilization and early active motion.

Where the neck is fractured and the head displaced from its articulation with the capitellum, a closed manipulation will usually fail, open reduction through a posterior incision should be done and the

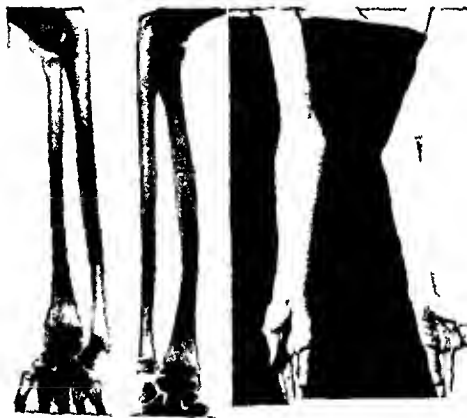


Fig 51 (Case XI) —Injury to upper end of radius at age of nine radial head removed at that time. Roentgenograms and photograph show the result four years later. There is a valgus deformity of the elbow with overgrowth of the lower end of the ulna producing a radial deviation of the hand and a prominence over the ulnar styloid.

head placed in its normal position. The forearm is then immobilized for four weeks with the forearm in supination, followed by active motion and the use of a sling for two weeks longer. Some limitation of rotatory motion is not uncommon following open reduction. These fractures include the epiphysis and the epiphyseal cartilage plate. If the head is removed, growth is arrested and a valgus deformity of the elbow will result with a radial deviation of the hand and a prominence of the distal end of the ulna. There may be some loss of rotary motion as a result of the disturbance of the distal radio ulnar joint.



CASE XI—M. O., aged 13 years, fell from a tree at the age of 9 and sustained a compound injury to the upper end of the radius (Fig 51). The radial head was removed at that time. Roentgenograms (Fig 51 A) and a photograph (Fig 51, B) show the result four years later. There is a valgus deformity of the elbow with overgrowth of the lower end of the ulna producing a radial deviation of the hand and a prominence over the ulna styloid. There is no disturbance of rotation but, as growth is not yet complete, the patient may still develop some restriction of this motion.

In cases of compound injury or irreparable damage of the head and the growth line, an arrest of growth of the distal end of the ulna should be performed at a suitable time following the injury in order to prevent the occurrence of this relationship. Parents should be instructed as to the possible outcome in cases in which growth arrest is likely to occur.

#### FRACTURES OF THE OLECRANON

Four patients in our series had fractures of the olecranon process or of the epiphysis. In only one was there any significant displacement. In this case the fragments were separated three-fourths of an inch and reduction was not satisfactory on extension. A longitudinal curved incision, with its convexity laterally, was made over the olecranon process of the ulna with exposure of the fragments and the lower end of the triceps. A small drill hole was made transversely in the upper end of the lower fragment half an inch below the end. A heavy braided silk suture was passed through the hole and through the triceps tendon and, with the elbow extended, the fragments were snugly approximated and the ligature tied. A light posterior mold was then applied extending from the top of the shoulder to the metacarpophalangeal joints, and the extremity supported in a sling. It is important not to apply a heavy cast and leave it unsupported as the weight of the cast will sometimes cause pressure on the fractured site and break the suture.

In cases where there is no separation or the epiphysis is involved immobilization either with a light posterior mold or an adhesive dressing around the elbow for two or three weeks with a sling will usually be sufficient. After the support is removed, the sling is used for a few days, during which time active motion is encouraged.

#### INTERCONDYLAR T OR Y FRACTURES OF THE LOWER END OF THE HUMERUS

Two such fractures occurred in this series, one of them compound. This condition is more frequently encountered in adults. The fractures are often comminuted and are usually due to a direct force. The pointed tip of the olecranon and the force may cause considerable separation and rotation of the fragments. There is usually a history of a severe injury, swelling and deformity are marked, and the demonstration of comminution suggests the diagnosis before the roentgenogram is made.

If there is little or no separation of the condyle, these fractures may need no special treatment, but where there is separation and comminution it is usually necessary to resort to traction. Open operation is not satisfactory because of the difficulty in fixing the fragments and the attendant joint damage.

CASE XII—J. K. aged 13, fell from a horse, landing on the tip of her left elbow. The fragments were manipulated by her physician and a splint applied. When seen ten days later roentgenograms (Fig 52, A) showed the condyles

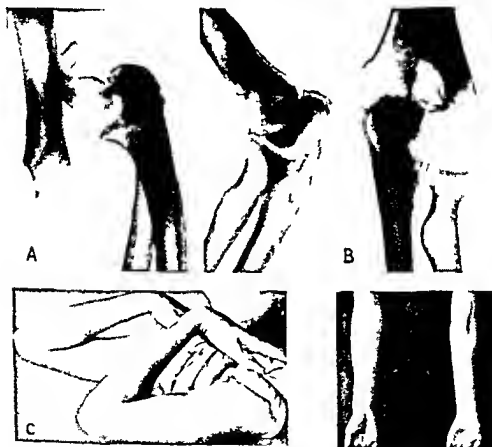


Fig 52 (Case XII)—A, Lateral view roentgenogram showing T fracture with wide separation of fragments. B, C, D, Roentgenograms and photographs four years after treatment by screw traction through upper end of ulna and excision of the tip of the olecranon.

markedly displaced and rotated. A screw was inserted into the upper end of the olecranon for three and a half weeks. A cast was applied for two weeks and then active motion was started while she carried the arm in a sling. One year later there was loss of the last 30 degrees of extension. The tip of the olecranon was removed and she gained 20 degrees of extension. Roentgenograms made three years subsequently (Fig 52 B) show a satisfactory reduction. There is limitation of the last 10 degrees of flexion and extension, and a slight loss of the carrying angle, noticeable only when compared with the other side.

In cases with a *compound injury* about the elbow which excludes the use of the screw, traction can be accomplished by adhesive on the forearm and a spreader beyond the fingers. A rope from the spreader goes to pulleys overhead with the arm at nearly a right angle. A piece of felt around the upper forearm makes traction in line with the arm.

CASE XIII—R. L., aged 11 was struck on the back of the left elbow by the handle of a car window while riding a bicycle. He was given emergency care and was brought to the hospital six hours later in a state of shock. Examination revealed marked swelling of the elbow and two large wounds over the posterior surface, one over the olecranon process of the ulna and the other—a ragged dirty wound—above through which half of the condyle was exposed, the articular surface being disarticulated. Roentgenogram (Fig 53, A) showed gross

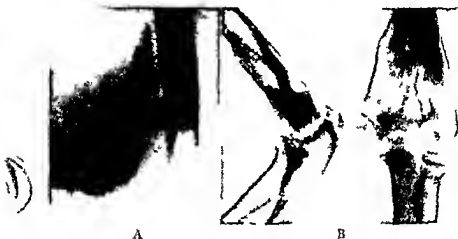


Fig 53 (Case XIII)—A Compound T fracture. Lateral view, roentgenogram shows fracture dislocation of medial portion. B, Roentgenogram showing appearance two years later.

displacement. The patient was given a blood transfusion and when his general condition improved, he was brought to the operating room. Under general anesthesia a blood pressure cuff was placed high as a tourniquet and the surrounding skin was thoroughly cleansed with sterile soap and water with sterile sponges protecting the wound. Gown and gloves were then changed and the wound itself cleansed with sterile soap and water and saline solution. The wound was then debrided and cleansed with normal saline. The entire medial condyle was lying loose in the soft tissue; it was removed and washed with saline. It was then replaced in its normal articulation and sutured to the lateral condyle by means of No. 1 chromic catgut passing through drill holes. The wound was closed and healed by primary intention. Traction was placed on the forearm attached to an overhead pulley with a piece of felt around the upper forearm and traction in line with the upper arm keeping the elbow at an angle of 90 to 100 degrees. Four weeks later healing was sufficient to maintain position; a posterior mold was applied and active motion begun. This was discarded in two weeks and the patient used only a sling. He gradually regained motion during

the next year and a half Roentgenograms made two years later (Fig 53, B) show the appearance at that time Motion was limited only in the extremes and there was no loss of carrying angle

#### FRACTURE OF THE CORONOID PROCESS OF THE ULNA

This is an infrequent type of fracture, occurring in only 2 per cent of this series It may be caused by hyperextension of the elbow, by injury forcing the humerus against the coronoid, or it may accompany a dislocation, it occasionally follows indirect violence, the brachialis anticus pulling it loose There is pain on pressure over the coronoid and on forced flexion Usually there is little or no separation, and a sling for a ten day to two week period is usually sufficient treatment

#### FRACTURE OF THE EXTERNAL EPICONDYLAR EPIPHYSIS

The external epicondylar epiphysis may be separated as a result of direct injury or adduction force to the forearm In such a condition there is pain and localized swelling over the epiphysis

The epiphysis is smaller and less subject to displacement than the medial epicondyle

Flexion and supination for two to three weeks is usually sufficient treatment

#### EPIPHYSEAL SEPARATIONS OF THE LOWER END OF THE HUMERUS

Separation of the capitellum is rare, in only one of our cases was the capitellar epiphysis itself displaced forwards Inasmuch as the medial portion is cartilaginous the x ray does not show its displacement After five years the capitellum separates with a small piece of the metaphysis rather than an epiphyseal displacement If the capitellum displaces forward, treatment in extension for two to three weeks may reduce it and result in healing

#### DISLOCATIONS

Seven dislocations were seen during the time 100 fractures about the elbow came under treatment Five of these were associated with separation of the internal epicondyle and some of these cases have been described under the treatment of that fracture Dislocation of an elbow unassociated with fracture is an uncommon injury in a child when compared to fractures about that joint

#### SUMMARY AND CONCLUSIONS

- 1 Elbow fractures constitute the second most common site of fracture occurring in children, the most common being the lower portion of the radius

- 2 Screw traction through the upper end of the ulna is the treatment of choice in certain displaced supracondylar fractures where closed manipulation fails and lateral adhesive traction is inadvisable

3 Displaced capitellar fractures usually require open reduction to accomplish a satisfactory result

4 Fractures of the radial neck with displacement should be replaced by open reduction if necessary, as removal causes a gradual increasing deformity of the elbow and wrist. In the occasional case where removal is unavoidable growth arrest of the lower end of the ulna should be performed in order to equalize growth of the two long bones of the forearm

5 Unreduced fractures of the internal epicondyle should be accurately replaced in order to obtain union and avoid local growth disturbance and subsequent ulnar neuritis. In older children the epicondyle can be removed and the fibrous muscular attachment sutured over the defect resulting in a more rapid recovery and without impairment from a cosmetic or growth standpoint

6 Dislocation of the elbow unassociated with a fracture is a rare injury as compared to fractures (2 per cent)

7 In cases that require reduction or where subsequent swelling is anticipated hospitalization and careful observation will reduce the incidence of complications

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## LESIONS OF THE WRIST

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BECAUSE lesions of the wrist joint are so numerous and the pathology entailed is so varied and extensive, the discussion of each entity must be brief. Roughly, the subject can be classified into four groups: congenital, developmental, infectious and traumatic. It is obvious that this classification cannot be too dogmatic and that certain entities under certain conditions could fall into more than one group.

### CONGENITAL LESIONS OF THE WRIST

As a rule, congenital abnormalities about the wrist joint are rare, but congenital fusion of one or more carpal bones is encountered not infrequently (Fig. 54). Such lesions may or may not be bilateral. X-ray examination of both wrists readily reveals this situation.



Fig 54—A case of congenital fusion of the semilunar bone with the triquetrum

Congenital absence of either the radial or ulnar epiphysis has been reported. In such cases there develops a real problem in the form of a growth disturbance. Obviously, the resultant deformity is most dis-

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abling as well as very unsightly. Fortunately there are surgical procedures which may be helpful in such instances. The accompanying illustration (Fig. 55) shows a case of congenital absence of the distal ulnar epiphysis which has definitely been improved by surgery. The distal end of the radius may be absent producing the so called club hand. Here again some form of osteotomy which may or may not be



Fig. 55—Upper Congenital absence of the distal end of the ulna and its epiphysis. Lower Postoperative result following osteotomy of radius and bone graft to ulna.

combined with bone grafting may be helpful. Such procedures if successfully carried out can be of great functional as well as cosmetic value.

#### DEVELOPMENTAL LESIONS OF THE WRIST

**Ganglion**—The ordinary ganglion is a common lesion which may occur at various locations but is frequently seen about the wrist joint, particularly upon the dorsal aspect. The exact etiology is not proved. Some believe that the ganglion is a herniation of the synovial membrane of a joint through a weakened area in the joint capsule. Others

feel that it is the result of colloid degeneration of the surrounding connective tissue. In most instances the ganglion is attached to the joint or to a tendon sheath from which it may also arise by a definite stalk. It is usually filled with a clear, jelly-like substance. If untreated it may progress to a large size. The treatment used to consist of rupture of the ganglion by direct pressure plus a compression bandage. However, such treatment frequently ended in recurrences. *Surgical excision* is probably most generally accepted as the treatment of choice. It must be borne in mind, however, that a recurrence of the ganglion will ensue unless the stalk is ligated well down at its base, namely, the joint capsule. X-ray therapy has been used with considerable success, as pointed out in a series of cases reported by Stublins.

**Madelung's Deformity**—This deformity is not too uncommon and has been described as a volar subluxation of the carpus. In reality this is

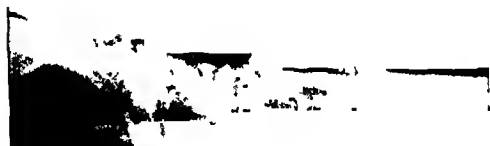


Fig 56—Madelung's deformity with definite limitation of pronation and supination

not the case, as the carpal bones are in normal relationship to the radius and the ulna protrudes on the dorsal aspect. There is a definite increase in the laxity between the radius and the ulna and, in most cases, there is a limitation of pronation and supination (Fig 56). The radius in many cases is curved toward the volar surface, but in some instances it is straight. This condition is usually bilateral and is usually first noticed in young individuals. A familial predisposition has been reported in about one third of the cases. As to etiology, there have been a variety of theories advanced, such as trauma, infection, rickets and osseous dystrophy. In those cases with a marked volar bowing of the radius the logical explanation is an early fusion of the volar half of the radial epiphysis. When there is no bowing of the radius, this explanation obviously is not adequate. Trauma must be considered as a cause, although the case in Figure 56 gives no history of injury. It is



conceivable that the condition could arise following repeated rotatory strains of the wrist as might be encountered in certain occupations thus producing an abnormally relaxed radio-ulnar joint. However, this would not likely account for a bilateral case.

#### FLEXION DEFORMITIES OF THE WRIST

An extreme flexion deformity of the wrist, no matter what the etiologic factor may be, is a very disabling condition. In the position of marked volar flexion the flexor power of the fingers is practically nil. As a result, the extremity involved is rendered almost useless. The most common cause of flexion contracture at the wrist is spastic paralysis, Erb's palsy and, occasionally, infantile paralysis. In many instances these extremities can be transformed from useless members to truly well functioning limbs by correcting the flexion deformity at the wrist. The most practical procedure in these cases is some form of *surgical arthrodesis*. One may use tibial grafts or iliac grafts. It is usually desirable in the deformities due to a spastic paralysis to have the grafts extend from the distal end of the radius well into the base of the third metacarpal bone. The ideal position of dorsiflexion is between 20 and 30 degrees. The wrist must be immobilized in a plaster cast for a long enough time to assure solid arthrodesis. In the case of a severe spastic immobilization may be necessary for from three to five months. For very severe flexion contractures, excision of the carpal bones as described by White is indicated.

#### INFECTIOUS LESIONS OF THE WRIST

**Tuberculosis of the Wrist Joint (Fig. 57)**—The wrist is one of the rarer locations of the tuberculous skeletal lesions. In children it is a very rare entity. In adults it frequently accompanies other lesions

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brane and tendon sheaths. In the chronic cases there are usually multiple draining sinuses. Due to the fact that the joint is so very superficial, the early symptoms and physical findings should make the diagnosis relatively simple. Swelling, pain, tenderness and an increase in local temperature usually appear in the early stages. X-ray findings which develop in due course consist of a thinning of the radiocarpal space with eventual erosion of the bones of the wrist. Along with these findings there is a definite decalcification of the bones of the carpus. As to treatment, one must consider that while the function of the wrist and hand is important, the eradication of a tuberculous focus is always paramount to the patient's general health. Consequently, whenever surgical measures can be employed in attaining this goal they are

definitely indicated *Excision of the carpal bones* in those cases where they are definitely involved will, in selected cases, not only give a good functional wrist, but will also, in some cases, eradicate a focus of infection. In cases where the radius is markedly involved, surgical arthrodesis should be performed wherever possible. Our experience with prolonged immobilization in plaster of paris or other forms of plints has not been very gratifying either as to function or as to arresting the disease.



Fig 57—Upper, Tuberculosis of the wrist Lower, Postoperative fusion bone chips having been removed from the radius

**Suppurative Arthritis**—This lesion may invade the wrist joint, since any pyogenic organism may attack any joint. This may come about as a direct process, as is seen in an open wound, or as a direct extension of an adjacent osteomyelitis of the radius ulna or carpal bones, or it may be blood borne from a distant focus. The clinical picture is that of a painful, tender, swollen joint with marked limitation of motion and muscle spasm. Accompanying these symptoms is an elevation of

temperature and an increase in the white count. The clinical picture varies in severity in direct proportion to the invading organism. Diagnosis can be made by aspiration and direct smear of the fluid within the joint. The milder cases with merely serous effusion may be treated by *repeated aspiration, local heat and sulfa therapy*. The more severe infections where a purulent exudate is aspirated call for *immediate and adequate surgical drainage of the joint plus proper sulfa therapy or penicillin*.

#### TRAUMATIC LESIONS OF THE WRIST

**Sprains**—Fractures about the wrist joint make up the commonest injury encountered by the surgeon. A simple sprain of the wrist is a relatively rare entity, and one should be cautioned against making such a diagnosis until after a thorough study of the injured part has been made. The usual postero anterior and lateral x rays are not sufficient to completely rule out a fracture, and these views should be supplemented by two oblique views, one in the semiprone and one in the semisupine position. If, after taking these views one cannot find a fracture yet definite point tenderness persists, a second set of films should be made two weeks later to rule out the possibility of a latent fracture. Not infrequently a fracture of the carpal scaphoid is not apparent at the original examination but is embarrassingly obvious if x rays are taken two weeks later.

A simple sprain should respond to the conventional treatment of *immobilization*.

**Lesions of Tendon and Nerve**—*De Quervain's Disease*, or stenosing tendovaginitis of the extensor pollicis brevis or abductor longus tendons, is a relatively common entity. The classical description was written by De Quervain in 1895. Since then, Stein, Finkelstein, Potter and a few others have contributed to the literature.

The characteristic  
thumb

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is particularly marked on grasping and radiates proximally up the forearm. Active extension of the thumb against resistance is always painful. Usually there is definite tenderness and in some instances slight swelling overlying the common sheath of the extensor pollicis brevis and the abductor longus muscles. The condition is probably due to repeated forceful adduction of the thumb from a position of marked abduction. In most instances, the cases that have been operated upon have revealed a definite thickening of the common sheath and of the overlying transverse carpal ligament. The treatment may be divided into two classes: *conservative and surgical*. The milder cases respond readily to complete *immobilization of the thumb and wrist* by means of a cellulose acetate cuff. It is essential that such a cuff extend from the interphalangeal joint of the thumb past the midforearm. This should

be worn from a month to six weeks, depending upon the severity of the symptoms. The more severe or chronic cases should be operated upon. *Simple longitudinal incision* of the dorsal carpal ligament and the common sheath usually is adequate. Stein has described a similar condition involving the sheath of the extensor carpi ulnaris tendon.

*Tenosynovitis of Flexor Tendons* of the wrist is a relatively rare complication that may occur following an incompletely reduced Colles' fracture and is due to the friction of the tendons passing over the anterior ridge of bone.

*Spontaneous Rupture of the Extensor Pollicis Longus Tendon* may occur following a posterior marginal fracture of the lower end of the radius. The tendon actually becomes so frayed that it wears out. End to end repair is usually difficult due to the lack of tendon substance. However, in some instances the distal portion may be sutured to either of the other two tendons of the thumb.

*Injury to the Sensory Branch of the Radial Nerve* occurs rather frequently following fractures of the lower end of the radius. After adequate reduction of the fracture the symptoms usually subside, unless, of course, there has been a complete rupture of the nerve.

*Injury to the Median Nerve* may occur following fracture of the lower end of the radius. The injury may be primary due to the original trauma. However, it may also be secondary due to pressure upon the nerve when the wrist is placed in the position of acute palmar flexion. Abbott and Saunders have described how the median nerve may be injured in this position due to pressure of the nerve between the transverse carpal ligament and the anterior border of the lower end of the radius. Delayed median nerve symptoms may develop in cases of malunion of the fracture of the lower end of the radius. In general, these nerve lesions are usually incomplete and the symptoms are transient. In some instances neurolysis is indicated.

*Fractures through the Lower End of the Radius*—In discussing these very common fractures, there are certain cardinal points that must be borne in mind. The most distal point of the styloid process of the radius lies about one half inch distalward to the tip of the ulnar styloid process and the articular surface of the end of the radius is tilted about 15 degrees toward the volar surface in respect to the long axis of the bone. Any fracture with displacement through the radius that does not involve the ulna will disturb the distal radio ulnar articulation. If the normal anatomical relationships are not restored following fracture of the lower end of the radius a perfect result cannot be obtained. If the full length of the radius is not re established limitation of supination will ensue. If the normal tilt volarward of the articular surface of the radius is not re established a limitation of the volar flexion will be inevitable.

*Colles' Fracture*—This is the most common fracture with which we

have to deal. It is a transverse fracture involving the entire thickness of the shaft of the lower end of the radius, the fracture line being located within one inch of the wrist joint. The distal fragment is displaced upward and angulated dorsally. There may be varying degrees of impaction. Clinically the hand is carried in radial deviation, the lower end of the ulna is prominent on the flexor surface of the wrist, and the hand is bent backward in a typical position, commonly known as the "silver fork" deformity. If the deformity is not adequately reduced, an unsightly, weakened hand results. Constant friction of the flexor tendons over the anterior ridge of bone may give rise to tenosynovitis, and there will be a loss of motion in supination and volar flexion.

Reduction of these fractures may be carried out either under local or general anesthesia. Strong longitudinal traction and forceful volar flexion will disentangle the fragments and reduce the deformity. In cases that are severely comminuted, the spread apart fragments may be literally squeezed together by the compression of the base of the operator's hands. Check up x rays should be taken after reduction and if these fail to show adequate position, a second attempt should be made. Needless to say the sooner these fractures are reduced the better, but it should be brought out that a poorly reduced fracture may still be corrected by the closed method up to two to two and a half weeks after injury. When properly reduced there is not much danger of the fragments becoming displaced. However, it is advisable to immobilize these fractures adequately and to recheck the position by x ray at a ten day interval. A circular plaster of paris cast split along one side with the wrist in moderate volar flexion and moderate ulnar deviation is preferable. The cast should extend from the base of the fingers to above the elbow.

The position of extreme volar flexion and ulnar deviation may give the surgeon a feeling of security regarding the position of the fragments but it has definite disadvantages. As mentioned previously the median nerve may be traumatized due to pressure between transverse carpal ligament and the lower end of the radius. Also when the wrist is placed in marked volar flexion it is very difficult to exercise the fingers efficiently. At the end of ten days the cast is changed and the wrist is placed in the neutral position. In most instances the cast is bivalved at three to three and a half weeks using only the volar half of the cast. At this point the splint may be removed daily for exercise and hot soaks. All support is discarded at the end of five to six weeks depending upon the patient and the severity of the fracture. Too much stress cannot be placed upon watching the circulation of the fingers, particularly during the first three days. If a circular cast is used, it should be split along one side immediately, as a safeguard against impaired circulation.

*Smith's Fracture, or Reverse Colles' Fracture* (Fig. 58) — This rare type of fracture is produced by falling and striking the flexed wrist. The distal fragment is displaced forward and upward. These fractures

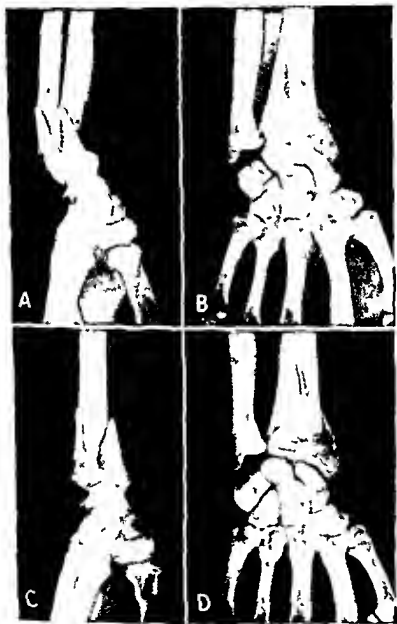


Fig. 58—A, B, Smith's fracture before reduction. C, D, Smith's fracture following reduction. Although reduction was not perfect, the end result was very satisfactory.

are usually comminuted. It is just as important to get an accurate reduction of these cases as it is in Colles' fractures. The same criteria are used for evaluating adequate reduction. These fractures can be reduced by strong traction and forceful dorsiflexion of the distal frag-

ment The wrist should be placed in moderate dorsiflexion and ulnar deviation The same after care and treatment as is used in Colles fractures is adequate

*Barton's Fracture*—This involves the dorsal articular margin of the lower end of the radius There is frequently no displacement of this fragment However when there is displacement every attempt should be made to replace the fragment This may usually be carried out by direct pressure with the hand and wrist held in moderate dorsiflexion After reduction the cast should extend from the metacarpophalangeal joints well up on the forearm with the wrist in slight dorsiflexion

The volar articular margin of the radius occasionally becomes fractured This is a rare entity and is sometimes referred to as a *reverse Barton's fracture* These fragments should be reduced by direct pressure and the wrist should be immobilized in moderate volar flexion for one week and after that it should be placed in the neutral position Both types of Barton's fracture should be immobilized in plaster of paris for about three weeks Following removal of the cast firm adhesive strapping is advisable

*Fracture of the Radial Styloid Process*—This is a relatively common injury and it is a very important one because of the fact that the fracture involves the articular surface of the radiocarpal joint In general these fractures are of two types (1) compression due to direct force and (2) avulsion due to the pulling force of the lateral ligaments of the wrist Those cases in which there is no displacement of the fragment require only simple immobilization with the wrist in ulnar deviation and in the neutral plane regarding flexion When there is displacement of the fragment the reduction is carried out by a combination of strong traction and direct pressure over the fragment In making pressure over the fragment one should keep in mind the normal contour and anatomic landmarks of the wrist Unless these relationships are restored one cannot expect the desired result In cases with displacement a circular cast is advisable similar to the one used in treating a Colles fracture fixing the wrist in ulnar deviation and moderate flexion if indicated The cast should be bivalved at three and a half weeks for exercise and hot soaks

The occurrence of a *fracture of the styloid process of the ulna* as an isolated fracture is quite rare Such fractures however do occur relatively frequently in the presence of other fractures about the wrist As isolated fractures they could readily be mistaken for a mere sprain of the wrist Usually the displacement is slight Immobilization of the wrist with the hand in ulnar deviation is the accepted method If after a month's time symptoms persist the immobilization should be continued for another few weeks Rarely is excision of the fragment necessary

*Dislocations*—Radioulnar dislocation is most important because it so

frequently accompanies fractures of the lower end of the radius. However, without fracture of the radius or ulna it is exceedingly rare. Usually the ulna is displaced toward the volar surface in respect to the radius. There is an abnormal mobility between the two bones and the patient complains of pain in the region of the wrist on both pronation and supination. The early cases may be reduced by manipulation and held by means of a plaster cast with the wrist in the neutral position. In cases of long standing or in those with a history of repeated dislocation, some type of plastic repair of the ligaments has to be resorted to.

**Fractures of Both Ulna and Radius Near Wrist (Fig. 59).—**Fractures of both the radius and ulna in close proximity to the wrist joint may

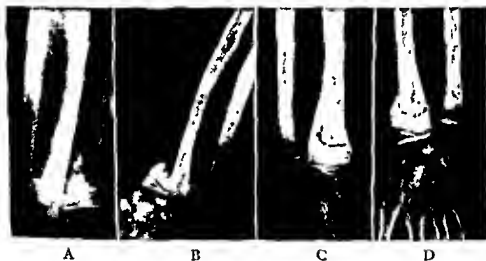


Fig. 59.—A, B, Bilateral fracture of the radius and ulna just above the wrist with marked displacement. C, Left wrist following closed reduction. D, Right wrist following open reduction.

show slight displacement and in such cases manipulation and proper immobilization are all that is necessary. However, when there is complete displacement of both fragments, the problem can be one of the most difficult to treat. It is advisable to try to reduce these by *closed manipulation* if possible. *Fluoroscopic control* in the reduction of these fractures may be helpful. If closed reduction fails, open reduction is indicated, and the use of a small skid will usually facilitate the actual process of reduction. The plaster-of-paris cast should extend from the base of the fingers up over the elbow in these cases.

**Displacement of the Distal Epiphysis of Either the Radius or Ulna (Fig. 60).—**This may occur either singly or in combination with a fracture of one of the bones about the wrist. The displaced epiphysis must be replaced as accurately as possible. The *closed manipulation* is by far the most logical method whenever possible. One should attempt



closed manipulation in every case before resorting to open surgery. The problem of reducing the displaced epiphysis is only a part of the dilemma that the surgeon faces. To maintain reduction may be more difficult than the act of reduction. In general, those cases that can be reduced by closed manipulation are much more readily held in the desired position.

In any injury involving an epiphysis there is always the question of a possible growth disturbance. In cases where there is a direct force and the epiphyseal plate itself is crushed, there is almost without exception a disturbance of growth even though the actual displacement of the epiphysis is minimal. Watson Jones has pointed out that in those



Fig. 60—A, Fracture of the radius with marked displacement of the distal ulnar epiphysis. B, C, After closed reduction. D, Five years later showing no growth disturbance.

cases where the force that produces the displacement is of a shearing type, true epiphyseal separation but not actual epiphyseal line separation. In such cases the developmental cartilage cells are not injured and, if the displaced epiphysis is reduced, growth will not be affected. This undoubtedly accounts for the fact that many markedly displaced epiphyses show no growth disturbance following reduction. A guarded prognosis in these cases is always advisable.

**Fractures and Dislocations of the Carpal Bones**—Fractures of the carpal bones are all too frequently undiagnosed and consequently neglected owing either to failure to examine the wrist by x ray or to

failure to take films in such a manner as will bring out the fracture, as has been mentioned previously.

*Fracture of the Navicular or Carpal Scaphoid Bone* (Fig. 61).—This is the most common of all carpal injuries and is usually produced by indirect force transmitted upward from the hand. Of course, direct violence over the dorsum of the wrist may produce a fracture of the scaphoid or of any other carpal bone. The most common type of fracture of the scaphoid is a fracture which runs transversely to the long axis of the bone at about the midline. This type is intra-articular. Fractures of the tuberosity of the scaphoid, which are very rare, are extra-articular. Occasionally one sees comminuted fractures of the

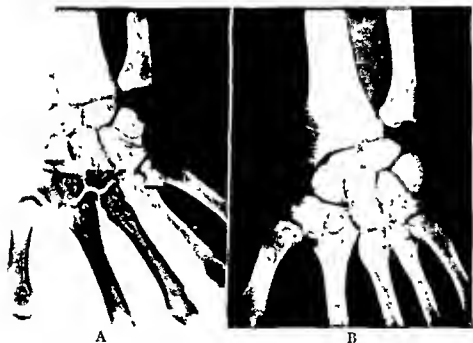


Fig 61.—A, Fracture of the carpal scaphoid. B, Result six months later following immobilization for ten weeks in a plaster cast.

scaphoid. In the ordinary transverse type, there is usually little displacement. In such cases the important point is the recognition and interpretation of the fracture; manipulation is rarely necessary. A good rule to follow is that every patient who gives a history of wrist injury and who has tenderness over the radial side of the carpus must be considered as having a possible fracture of the navicular until repeated and complete x-rays have ruled it out.

The prognosis in these cases is usually good if they are recognized early and are immobilized properly. However, the situation must be thoroughly explained to the patient at the beginning of treatment. To make light of these fractures and to treat them in a haphazard manner is to court disaster.

Immobilization should be obtained by a tight fitting circular plaster of paris cast which includes the thumb and extends from the base of the fingers well up the forearm. Moderate radial deviation and dorsal flexion of the hand with the thumb in abduction is the ideal position. If the cast should become loose it should be replaced. Otherwise it should be left on for six weeks and x ray examination made. If union

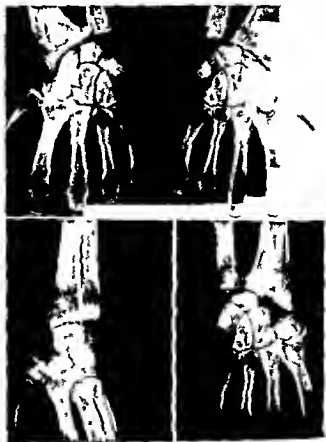


Fig. 62—Upper, Preiser's disease of the left carpal scaphoid (the right wrist is shown for comparison). Lower, After surgical excision of the scaphoid.

is not definitely evident a new cast should be applied for another four to six weeks. Prolonged immobilization may be necessary. In cases that are unrecognized in the early stages or in those that are improperly treated nonunion may ensue. It will also follow occasionally in those cases that are adequately treated. If in these cases pain and weakness of the hand persist further treatment is indicated. If the two fragments appear viable, the density of the fragments by x ray being nor

mal, an autogenous bone peg may be placed through the fragments with good results. In some instances one or both fragments become more dense due to a loss of circulation and aseptic necrosis follows. In such cases excision of one or both fragments may be indicated. Aseptic necrosis of the carpal scaphoid is known as *Preiser's disease* (Fig. 62).

*Dislocation of the Lunate or Carpal Semilunar Bone.*—This relatively common injury to the carpus frequently accompanies another injury

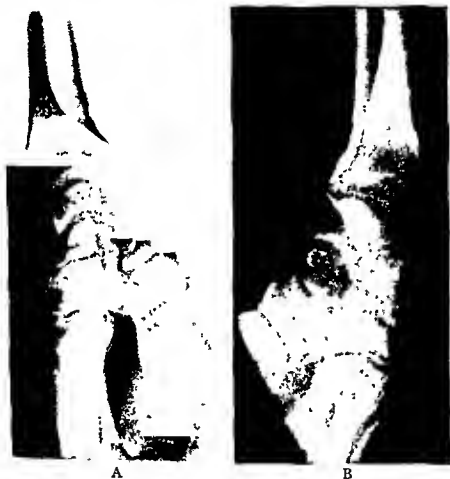


Fig. 63.—*A*, Lateral view of the normal wrist. *B*, Lateral view showing the dislocated semilunar bone.

such as a fracture of the scaphoid. In most instances it is dislocated toward the volar surface as the mechanism is one of indirect force transmitted through the hyperextended wrist. An ordinary lateral x-ray readily establishes the diagnosis (Fig. 63). With marked volar displacement of the lunate, median nerve injuries are not infrequent. Inasmuch as the ligaments are extensively torn and detached from the bone in such cases, there quite frequently is a disturbance of the blood supply with a resulting aseptic necrosis which is commonly known as



Fig 64—A Typical case of Kienbock's disease B Postoperative picture following excision of the semilunar bone C Another case showing a typical Kienbock's disease

*Kienbock's disease* (Fig 64) As the areas of absorption increase in the bone collapse is inevitable. Eventually the bone flattens out and its articular surface becomes irregular. Due to this collapse impaction

occurs and the bone may appear more dense by x-ray. This usually leads to a painful wrist with definite limitation of motion. While it is true that normal texture of the bone may recur, the irregularly shaped articulation is painful and excision of the bone may have to be resorted to.

Dislocation of the lunate can usually be reduced by closed manipulation. An anesthetic is necessary, following which hyperextension of the wrist opens up the space and direct pressure over the displaced bone will usually snap it into place. The hand and forearm should then be immobilized in volar flexion for a week. At the end of a week the neutral position may be maintained for three more weeks.

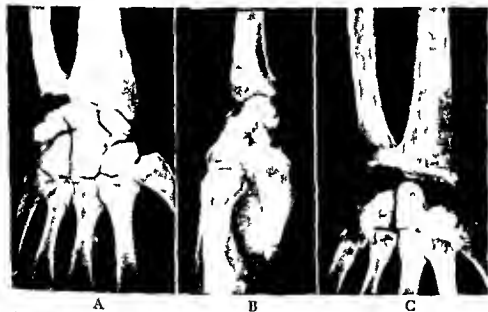


Fig 65—A, B, Fracture of the carpal scaphoid and pisiform bones and dislocation of the lunate. C, Result following surgical excision of the scaphoid, semilunar and triquetrum.

*Comminuted Fractures of the Carpal Scaphoid with Dislocation of the Semilunar Bone*—Occasionally one sees extensive injuries of the wrist where the combination of fractured fragments plus the dislocation is such that the situation is not amenable to closed manipulation. In such instances open reduction is indicated. If after thorough examination the comminuted fragments are such that it does not appear that they can be replaced satisfactorily or if the blood supply appears to be too greatly disrupted, excision of the scaphoid, semilunar and triquetrum may be indicated (Fig 65). Such a procedure may sound radical, but in selected cases it has been found to be highly desirable. The economic factor involved in a case of Preiser's disease or Kienbock's disease or a combination of both must be considered in making such a decision. Excision of the proximal row of carpal bones will give

a very good functional wrist. It is true that there will be a definite limitation of motion but painless motion in the position of moderate dorsiflexion can be obtained.

*Fractures of the other carpal bones* do occur but are quite rare. The treatment lies primarily in reduction by manipulation and immobilization with an adequate cast as in the other injuries.

**Traumatic Arthritis of the Wrist.**—This condition may occur following comminuted fractures of the articular surface of the radius or in fractures of the scaphoid. If prolonged immobilization does not relieve the painful symptoms, surgical fusion of the radiocarpal joint may be carried out, taking care not to fuse the distal radio-ulnar nor the carpo-metacarpal joints.

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# THE TECHNIC OF PLATING LONG BONE FRACTURES

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In discussing the technic of plating long bone fractures this morning I want to state right off that I am not yet convinced that every such fracture should be plated, and I appreciate that there are plenty of fractures where plating is impracticable, such as those near joints with extreme comminution. Nevertheless, with improvement in the asepsis of our surgery, the screws and plates now available and the mechanics of their application, plating does afford a safe and dependable means of internal fixation which both facilitates healing in good anatomical position and minimizes the need of external splints there by shortening the period of disability.

## ILLUSTRATIVE CASES

### Case I—Fracture of the Ulna with Dislocation of the Head of the Radius

The first case I want to present illustrates a fracture which would be very difficult to hold by any other means than internal fixation. This patient is a civil engineer by the way, and because of the difficulty he had with his fracture became very much interested in the mechanics of bone plating and has been of great assistance to me in solving some of the problems involved. He fell on his left elbow when a small rug skidded with him and as you see from this first film (Fig 66 A), broke his ulna about  $1\frac{1}{2}$  inches from the olecranon and also dislocated the head of the radius. His local surgeon, an excellent man, tried to keep both of these conditions reduced by a cast and when this failed sent him to an orthopedist in a near by city. There attempts were made to maintain reduction by means of pins through the upper arm and forearm with external traction and when this failed the ulna was wired as you see in the next film (Fig 66 B). After six months there was angulation, nonunion and a persistent dislocation of the radius. I removed the head of the radius, took out the wire and then after freshening the ends of the fracture applied a plate (Fig 66 C). This plate was of course just under the skin and after it had served its purpose (about eight weeks) it was removed (Fig 66 D) and good bony union was observed. Through persistence the patient has regained practically full use and strength of this arm.

### Case II—Fracture of the Tibia

The second case illustrates another nonunion of long standing. This time of the tibia where a Hawley plate was of much assistance in promoting bony union, I believe. The first film (Fig 67, A) shows how much increase in density had taken place. The patient had had several operations on his leg all per

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formed by excellent orthopedists, the last a large sliding bone graft. Incidentally, he had syphilis, for which he could never be persuaded to take more than occasional treatments, but I do not believe this was a prominent factor in the non-union. Although he had come from quite a distance I sent him home for four

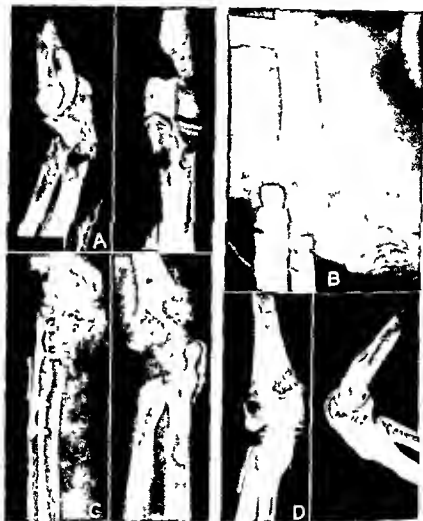


Fig 66 (Case 1) —A, Fracture of ulna  $1\frac{1}{2}$  inches from olecranon, with dislocation of head of radius B, After wiring of the ulna C, The wire has been removed, the ends of the fracture freshened and a plate applied D, After removing plate Good bony union achieved

months for antisyphilitic treatments because I did not want to operate upon him while he had a positive Wassermann reaction, but when he returned his reaction was still positive and he admitted he had had only a few treatments 'because it was so inconvenient to get to the doctor'.

While my assistant and one intern were preparing the fracture to receive the

graft, another intern and I cut a massive graft from the other tibia. It is advantageous to have two teams for such a job. There is, among other things, no chance then of carrying infection to the donor site. This massive graft was placed on the posterior aspect of the broken tibia (onlay) and anchored snugly by metal screws. The holes for these screws had been drilled in the graft just before it was cut loose from the tibia—an easy time to drill them. I was not



Fig 67 (Case II) —A, Fracture of tibia with nonunion. Note increase in density. B, After application of massive graft and Hawley angle plate.

satisfied to trust to the immobilization of this onlay graft alone, so a Hawley angle plate was applied to the anterior surface of the tibia. These plates well applied can be depended on to afford complete immobilization (Fig 67, B). The patient went on to good union with very little loss of function at the ankle.

### Case III—Use of Transfixion Screws in Fracture of Femur

The third case illustrates the use of transfixion screws to approximate widely separated fragments in an old fracture. This man had been treated by Buck's extension first and then by means of two pins through the lower end of the femur. After five months there was no union and a wide separation of the fragments (Fig 68 A). One could almost predict that there would be interposed tissue and at operation we found muscle from behind the thigh filling the gap between the fragments. After replacing this and freshening the surfaces a bit the fracture was reduced as well as could be and two large screws were in

serted to draw the fragments into close approximation. To accomplish this it is, of course, necessary that the drill holes in the proximal fragment be slightly larger than the outside diameter of the screw so that as the screw is turned it can draw the fragments together. Then a large plate was placed on the anterior surface of the femur, this time we used a McBride plate because its many holes gave us a greater chance to place our screws in solid bone (Fig. 68, B). With the two transfixion screws going in the lateral aspect of the femur and the plate



Fig. 68 (Case III) - 4, Fracture of femur, nonunion after five months. Note wide separation of fragments B. The interposed tissue has been replaced, the surfaces freshened and screws inserted. McBride plate placed on anterior surface of femur.

be complete here, callus is shown in the latest x rays and the patient more weight on the leg right along. Just one word of caution before we leave this case. There is an unavoidable loss of blood in operations on femoral fractures such as this and transfusions are to be taken as a matter of routine.

#### Case IV.—Transfixion Screws in Fracture of Tibia

The fourth case I want to show very briefly just to emphasize how important it is to use transfixion screws wherever possible. This man had a large third fragment, triangular in shape, broken loose from his tibia, as can be seen in

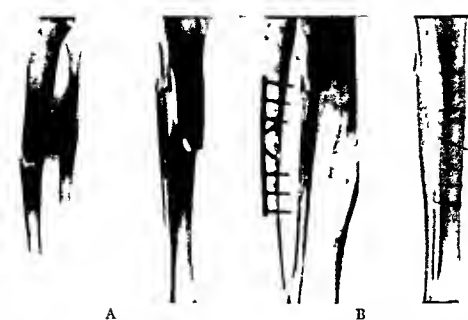


Fig 69 (Case IV) -A, Fracture of tibia with large third fragment broken loose  
B, After application of screws and plate



Fig 70 (Case V) -A, Fracture of upper third of humerus, occurring seven years after fracture of lower third Note old plate on lower third of bone B, After plating of second fracture

Figure 69 *A* It would have been practically impossible to have held that large fragment back in place without internal fixation. By means of a plate and two screws angulated so as to transfix this fragment it could be held nicely (Fig 69 *B*)

### Case V—Application of Second Plate in Fracture of Humerus

This is the only patient on whom I have had the opportunity of applying a second plate on a bone I had previously plated. Seven years ago he broke the lower third of his left humerus which was plated and now he has come back with a fracture in the upper third. Closed reduction of this fracture could not be effected so we had to assume the interposition of soft tissue and at operation our assumption was verified. In these pictures before and after the plating of his second fracture you can see the old plate still on the lower third of the bone (Fig 70 *A B*)

### EQUIPMENT AND TECHNIC

I should like to discuss now the tools and equipment I consider essential for a good plating job. It can of course be taken for granted that the surgeon will be careful about asepsis, not touching the skin

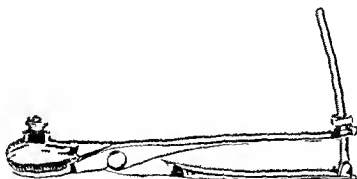


Fig 71—Goodwin bone clamp with adjustable drill guide

even though it has been well scrubbed and prepared and changing the gloves if this happens accidentally (this applies to assistants as well). As soon as the incision (which must be adequate) has been made, the skin edges are covered with towels, well secured. So called "no touch" technic is then not necessary. The fracture may be reduced as well as possible by whatever means seems applicable to the particular situation. It pays to incise the periosteum so that it may be dissected away from the bone with the overlying muscles as plates are always applied under the periosteum. Frequently the fracture will not stay put without the aid of a bone clamp. There are several modifications of the Lowman clamp, each having some advantageous features. This Goodwin clamp (Fig 71) has an adjustable drill guide

and the ratchet which locks the handles measures the thickness of the bone, thus indicating about the length of screw to use

Plates—At this point the type of plate best suited to the fracture should be selected. As to material, either a good stainless steel, such as that usually called 18-8 SMO, or vitallium, is satisfactory. Vitallium,

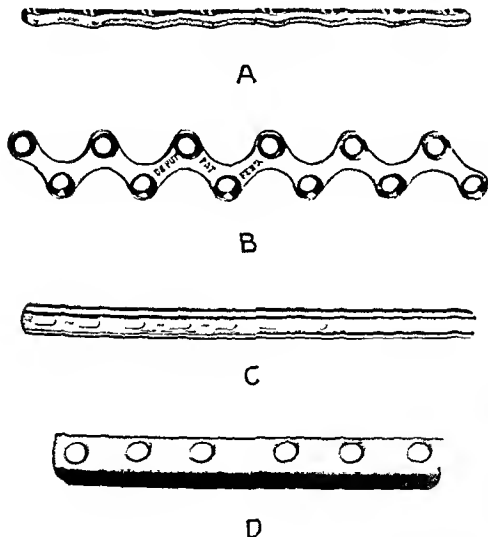


Fig 72—Types of fracture plates A, Sherman plate B, McBride plate C, T and G plate D, Hawley's angle plate

being very hard and cast, is more subject to certain flaws, such as air holes, but every screw and plate is now x-rayed before being released by the manufacturer. On the whole, the *Sherman plate* (Fig 72, A) is most generally acceptable, but in some badly comminuted fractures especially, a *McBride plate* (Fig 72, B) may permit you to anchor

more fragments. The *T & G plates* (Fig 72, C) have the advantage of being longer, are easily bent to conform to the bone surface and because of this several must be nested together to obtain sufficient rigidity. And speaking of rigidity, *Hawley's angle plate* (Fig 72, D) affords the most perfect immobilization, when it can be used. Obviously a saw cut must be made lengthwise of the bone across the fracture to receive one flange of the plate. Before leaving the subject of plates I can't refrain from emphasizing how sorry I am that the manufacturers ever got away from Sherman's original design, which called for a plate that was curved to fit humerus or femur, and was both wider and thicker—especially at the edges—in the center portion, where most of the strain comes, and where plates break.

After the plate has been selected, it should be placed most advantageously and held securely by the bone clamp while the holes are drilled and the screws inserted. Frequently the plate has to be bent a little so that it will conform to the bone surface. In doing this bending one must be as careful as possible not to injure the surface of the plate and to make the bends gradual rather than angular. Irons used

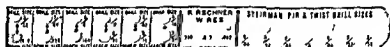


Fig 73—Gauge for measuring drills and screws

in bending the plates should either have rubber over the jaws, or the jaws should be of a soft metal, such as aluminum. Perhaps it will seem wiser to place a couple of transfixion screws before anchoring the plate with its screws, or sometimes the two screws adjacent to the fracture can be angulated so as to transfix both fragments, as in Case IV above. And may I repeat, if the transfixion screws are to pull the bone fragments together the hole in the proximal fragment must be slightly larger than the screw and that in the distal fragment small enough for the threads to engage.

**Drills and Screws—Drills**—We are now ready to drill the holes for the screws. The drill size should be just slightly larger than the root diameter of the screws. Such a gauge as that shown in Figure 73 can be sterilized and is a great convenience in estimating both screw and drill sizes. I have found that the cheap 5 and 10 cent store wire drills have one decided advantage and that is that they will bend rather than break. They vary considerably in size so each one must be measured, either with a gauge or a micrometer, and they dull quickly. The high speed drills remain sharp longer and are more uniform in size, but they will break, not bend, under accidental lateral pressure. There are just

two ways I know of for keeping the drill centered in the hole of the plate as you drill into the bone, one is by the aid of a small drill-centering jig (Fig. 74), the other by first making a few turns with a larger drill, one whose beveled end just fits into the bevel in the hole of the plate, as recommended by Mr. Zimmer. A  $\frac{3}{16}$  inch drill is about right for this, but the cutting lip should be ground at an acute angle

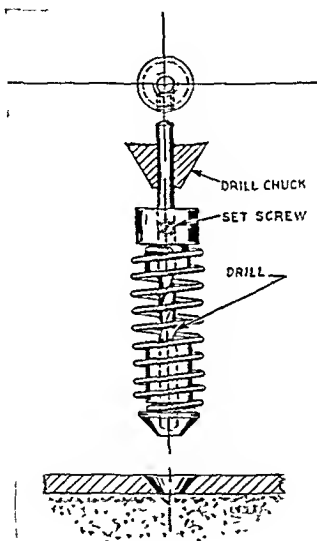


Fig 74—Drill-centering jig

making a more pointed drill. Of course, both bone and drill should be held as still as possible during the drilling so that the hole will not be more oval than necessary. Carnes photographed holes drilled in bones under operating room conditions, not at work benches, and found they were all somewhat oval. As you drill through the distal cortex the hole in the near cortex acts as a guide, so the holding power of the screw





Fig 75 -Depth gauge for ascertaining proper length of screw

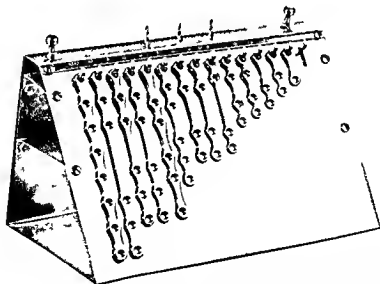
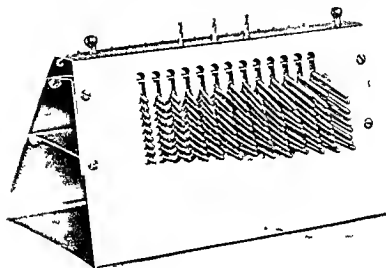


Fig 76 -Stainless steel screw and plate holder upper view shows side with screws, lower opposite side with plates (Proper size drills are seen in the top of the holder )

should be greater in the distal cortex—another good reason for putting all screws through both cortices

*Screws*—The proper length of screw to reach through and slightly beyond the distal cortex can be ascertained by placing a clamp on the drill just as it emerges through the bone, or by using a depth gauge like the one in Figure 75. The extraction of such a gauge is facilitated by having an indicator, such as a flattened surface, on the handle to show which way the hook is pointed. To have at hand screws of various lengths a stainless steel screw and plate holder has been made (Figs 76 A, B). In the top are holes which serve as gauges for the correct size drill for these screws, and a depth gauge. The type of screw selected will vary somewhat with the bone to be plated. That is in a femur, humerus or tibia a coarse thread (18 or 20 per inch) is better, but in bones with a thinner cortex, such as forearm and especially metacarpals and metatarsals, a finer thread (28 to 32) will hold

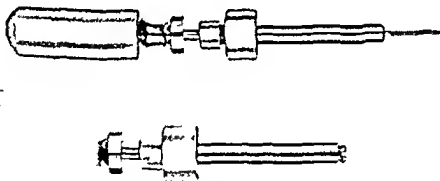


Fig 77—Screw driver for holding screw in line and rigid

better. All of the screws are self tapping, and contrary to the opinion held by most surgeons this does not mean they must have a flute, or groove, the flutes actually lessen the holding of the screw in the distal cortex unless the flute is very short and screwed entirely through the bone.

*Insertion of the Screws*—Probably the most important part of the insertion of the screw is its beginning. To start the screw well requires first of all a screw driver, such as the one in Figure 77, which holds the screw perfectly in line and absolutely rigid, nothing less will suffice. Then the screw is turned in slowly with a moderate amount of steady pressure until it is obvious that the threads are well engaged. Before the screw is given its last few turns the holding jaws of the screw driver must be released so that the screw can be firmly seated, but the jaws should be so constructed that they will not permit the screw driver to slip off the screw. Such a screw driver accomplishes what can other-

wise be done only by means of the Phillips recessed head. If the drill size is right and the screws were started carefully they may be turned down firmly with no fear of stripping. Of choice, all of them should go through both cortices, and then, with an average femur, each screw will withstand a pull of upwards of 1,000 pounds.

**Closure of the Wound**—In closing these wounds, and for ligatures I prefer either cotton or a fine (not larger than 00) chromic gut, and some sulfa crystals may be dusted in if desired. After the skin is closed and sterile dressings laid over the incision, fluffs or a good grade of mechanics' waste should be applied and wrapped snugly with an elastic (Ace or similar) bandage, to afford gentle compression.

**Postoperative Care**—The limb should be placed in balanced suspension. This will permit motion—slight at first—of the adjacent joints, as soon as the postoperative pain begins to recede. After the proper application of a satisfactory plate and with transfixion screws a plaster cast will seldom be necessary, and the period of disability will be materially lessened if motion in adjacent joints can be permitted while bony healing is taking place.

**Removal of Plates**—One question that always comes up in regard to bone plates is whether they should be removed, and the answer is they should not unless they make trouble. Those that are subcutaneous as on the ulna or tibia, more frequently cause trouble, but a plate may break and cause some irritation years after its application, probably from the frequent, though slight, bending every long bone goes through in our daily activities. But regardless of the cause, any plate that makes trouble should be removed, it will have served its purpose after two or three months, usually. The possible exception is compound fractures which were treated by packing the wound open with petrolatum gauze after a thorough cleansing and plating. And here I believe, you will find that plating is not only of invaluable assistance in keeping the bone ends in apposition while the wound is healing but renders the unavoidable handling of the patient and broken member infinitely easier and less painful.

# DIAGNOSIS AND TREATMENT OF INTERNAL DERANGEMENTS OF THE KNEE

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MEDICAL CORPS, ARMY OF THE UNITED STATES

THE number of young men unfit for military duty because of "internal derangement of the knee" is very large. On the orthopedic service in any Army general hospital in this country one will find many healthy soldiers who can not carry on with military duty because of knee disabilities. The majority of these cases fall into the group of internal derangements of the knee. A certain percentage have had previous operations without relief. A large number have varying degrees of instability of the knee resulting from old ligamentous injury which was usually unrecognized at the time of the original injury and, as a result, was initially inadequately treated.

Too frequently there is a tendency on the part of the examining physician to use "internal derangement of the knee" as a diagnosis. The term "internal derangement of the knee" is a general term, used to cover a multitude of conditions affecting the knee. The commonest

## ONE HUNDRED CONSECUTIVE CASES OF KNEE JOINT DERANGEMENT ADMITTED TO GARDNER GENERAL HOSPITAL

1 Dislocation of articular cartilage	
(a) Medial meniscus	32
(b) Lateral meniscus	5
(c) Both menisci	2
2 Ligamentous injury	
(a) Internal lateral	11
(b) External lateral	1
(c) Combination, including lateral and cruciate	10
3 Cyst of lateral cartilage	13
4 Fracture of tibial spine	10
5 Calcified hematoma	4
6 Dislocation of patella	4
7 Fracture of tibial spine	4
8 Cyst of lateral cartilage	3
9 Calcified hematoma	1

causes for the so called internal derangements are injuries to the semi-lunar cartilages and varying degrees of strain or tears of the intrinsic or extrinsic ligaments. There are, however, other conditions which must be included in this classification because of the difficulties encountered in a differential diagnosis.

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To obtain the best results in the treatment of knee injuries accurate diagnosis must be made and proper treatment instituted immediately. This is most true in cases of ligamentous injury. It is my feeling that proper early treatment for ligamentous injury of the knee, whether it be surgical or conservative, will, in the greater percentage of cases give good results, while late attempts to repair ligamentous injury about the knee have thus far been discouraging, if not hopeless.

For the purposes of this paper 'internal derangements of the knee' will include

- 1 Disturbances of the semilunar cartilages
  - (a) Tears
  - (b) Cysts
- 2 Disturbances of the collateral and cruciate ligaments
- 3 Disturbances of the articular cartilage
  - (a) Osteochondritis dissecans
  - (b) Chondromalacia of the patella
- 4 Dislocation of the patella
- 5 Disturbances of the fat pads
- 6 Other derangements
  - (a) Fractures
  - (b) Osteochondromatosis
  - (c) Synovitis
  - (d) Pellegrini Stueda's disease

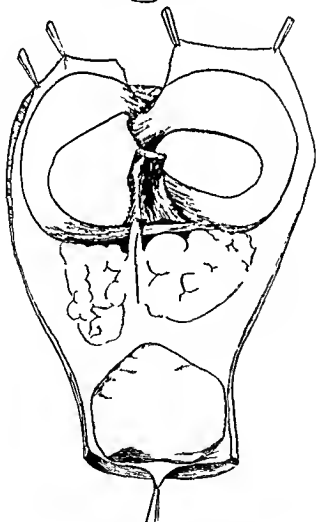
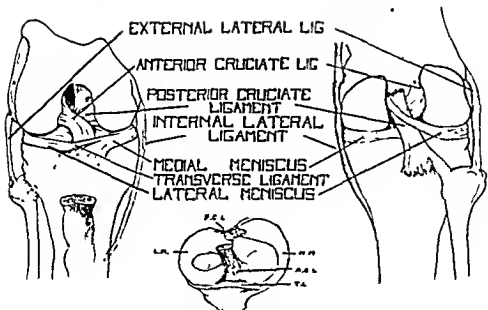
#### ANATOMICAL CONSIDERATION

To evaluate knee injuries a sound understanding of the anatomy is necessary (Fig 78). No general description is to be given here. Excellent work by Brantigan and Voshell,<sup>1</sup> Abbott, Saunders and others,<sup>2</sup> has demonstrated the anatomy of the knee and its associated structures. Emphasis should be placed, however, on the importance of the supporting musculature, especially the quadriceps femoris. This muscle is the principal mechanism to prevent rotation between the tibia and femur until the knee is locked in extension. Weakness of the quadriceps will allow strain on the supporting ligaments. This is especially true in regard to the vastus internus, for this portion of the quadriceps group is quite selective in its action. The last 15 degrees of extension is performed almost entirely by the vastus internus. This muscle is quite important in stabilizing the joint in all positions, and weakness of this muscle is almost entirely responsible for the frequently presented symptom of the knee "giving way" under sudden stress or strain. The first maxim in treatment of knee conditions is to strengthen the quadriceps. This is the first line of defense, for without adequate quadriceps power a normal knee will not be obtained.

The semilunar cartilages are avascular except at their periphery, the site of attachment of the coronary ligaments. For this reason when a longitudinal split occurs no healing can be expected, except for those

Anterior

Posterior



Articular surface left knee

Fig 78 -Anatomy of the knee joint.

tears in the region of the coronary attachment. The internal semilunar cartilage is smaller and less complete than the external cartilage. It is also more fixed at the periphery, allowing for its more frequent injury. The external cartilage is larger and more circular in shape, and it is less fixed. The coronary ligament allows freer excursion of the cartilage because of its greater length and because of the gap which occurs posteriorly in connection with the popliteus muscle.

#### DISTURBANCES OF THE SEMILUNAR CARTILAGES

**Tear of the Internal Semilunar Cartilage**—There is little difficulty in the diagnosis of recurrent displacement of a cartilage when the patient states he injured his knee some time before and that since the injury he has had repeated occurrences of locking, with certain positions or

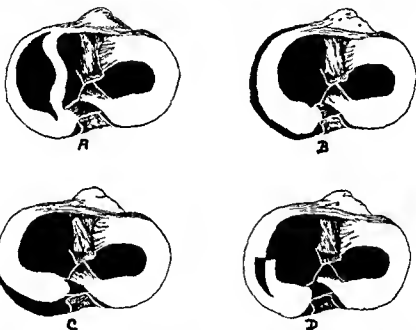


Fig. 79—The more common injuries to the internal semilunar cartilage. *A*, Bucket handle tear. *B*, Peripheral detachment. *C*, Detachment posterior horn. *D*, Posterior tear.

movements the knee would catch and would not straighten beyond 150 to 170 degrees, pain was noticed on the inner side of the joint line, after manipulation something gave way, and the knee could be straightened, there was some swelling after each episode. These symptoms are characteristic of a recurrent dislocation of an articular cartilage. Only a loose body need be excluded, and this most usually may be done by an x-ray study.

The diagnosis in the original injury is much more difficult. This diagnosis is based primarily on the history of the accident, as too frequently the locking of the knee has been relieved before examination. The mechanism of injury for an internal semilunar cartilage is a rotation abduction strain of the partially flexed knee with weight on that leg such as would occur on a sudden pivoting, or upon being tackled from the side while the weight was on that leg and the knee flexed. The force need not be great. In one case the injury occurred when the patient was getting out of a seat at a theater. There is immediate acute pain over the medial side of the joint and inability to extend the knee beyond 150 to 170 degrees. Flexion may be approximately normal. Frequently the patient has a sensation as of something wedged between the joint when extension is attempted, and this is of considerable diagnostic importance. The patient walks on the toes of the affected leg, unable to bear weight with the knee extended.

*Examination*—There is usually swelling of the knee joint with fluid present which is usually bloody on aspiration. There is local tenderness over the anterior joint line between the internal lateral ligament and the patellar tendon. The point of tenderness is important and, if the tender point is over the medial ligament, great caution as to the diagnosis of a torn cartilage must be observed. If the knee is still locked, forced extension will be painful. There will be no instability in either the lateral or anteroposterior direction if the ligaments are intact. Whenever there is doubt as to ligamentous relaxation, and examination cannot be thoroughly made because of pain and muscle spasm, examination of the ligaments should be made under anesthesia.

*Treatment*—1 Recurrent dislocation of an articular cartilage is remediable only by surgical excision of the injured cartilage, either of the torn portion or the entire cartilage.

2 It is the author's opinion that immediate surgical excision is also the treatment of choice in the acute cartilage injury. However in doubtful cases or where surgery is refused, replacement by manipulation with or without anesthesia, may be attempted. In many cases where pain is acute, manipulation without anesthesia will be unsuccessful. Following reduction, the knee should be supported with a compression bandage and put at rest in either a posterior splint or a cylindrical leg cast, extending from the upper thigh to the lower leg. Quadriceps drill should continue until the thigh measurements are equal. Support for three or four weeks is advisable. It is frequently amazing to find the marked atrophy of the thigh which may occur following even a simple injury to the knee.

If the injury to the cartilage is a *longitudinal tear*, the chances of permanent healing are remote, and recurrences may be expected. This repeated trauma before surgery is instituted will definitely diminish the opportunity for an excellent result. Each recurrence is occasion



for further synovial changes, and repeated trauma leads to an irremediable arthritic process. Long standing recurrent dislocations also lead to severe atrophy of the quadriceps, which is extremely difficult to overcome and, when not corrected, leaves a weakened and susceptible knee, even after adequate surgery.

*Tears of Posterior Horn*—The above description has considered the classical longitudinal tear of the internal semilunar cartilage, usually occurring in the anterior one-half or two thirds of the cartilage. There is a very definite group of cartilage injuries which do not follow the classical description, and in which the tear is present in the posterior horn. It is extremely important to recognize this group in order to adequately treat knee injuries. Bristow,<sup>2</sup> in reviewing 629 longitudinal tears, found 31 per cent were of the posterior portion of the cartilage.

In lesions of the posterior horn the usual classical history is not present. The mechanism for injury may be the same, i.e., flexion abduction and rotation, but, in our experience, posterior horn lesions frequently occur when the knee is in full flexion, such as when in the squatting position, and then a rotary or twisting motion is applied. In these posterior tears the lesion is localized and consists of a small pedunculated flap, or loose posterior horn. The symptoms are usually a feeling of insecurity in the knee, especially in flexion, as noticed in going down stairs. Frequently full flexion is accompanied by an audible 'click' or 'clunk.' Localization of pain by the patient is difficult.

*Clinical examination* may elicit extremely meager findings. Occasionally, there may be a mild synovitis. The ligaments are not tender, and the knee is stable. The most important finding is a sign described by McMurray: 'Test for posterior horn lesions'—"In using this method the knee should be flexed completely, so that the heel rests on the buttock or as near this point as possible. The ankle is then grasped in the right hand, and the joint controlled by the left hand with the thumb and forefinger firmly grasping it on either side at the level of the joint to its posterior aspect, and behind the external and internal lateral ligaments respectively. The ankle is now twisted by the right hand, so that the knee is rotated inwards and outwards to its fullest extent, and if a lesion of the external cartilage or of the posterior portion of the internal cartilage is present, a definite click may be felt under the finger or the thumb of the left hand. Examination of an abnormally lax knee joint in which there is no lesion of the internal or external cartilages may give a sensation which might at first be mistaken for this click, but in such a case the click is not definite, and there is not the peculiar sliding or gliding of the femur over an apparent obstacle which is so typically present when there has been an injury to the external cartilage or to the posterior portion of the internal."

A test for posterior horn tears may be considered positive when a patient is requested to assume a full squatting position, and at the point

of complete flexion a very palpable and audible "click" or "clunk" can be felt and heard, as the condyle of the femur passes over the torn position of the cartilage. The fact that a posterior horn injury may be found with a classical longitudinal tear of the anterior portion of the cartilage makes complete inspection of the cartilage advisable at the time of surgery.

**Tears of the External Semilunar Cartilage**—Tears of the external semilunar cartilage similar to those just described for internal semilunar cartilages are not uncommon and their incidence is greater than is usually appreciated. The incidence in the Bristow<sup>2</sup> group of over 600

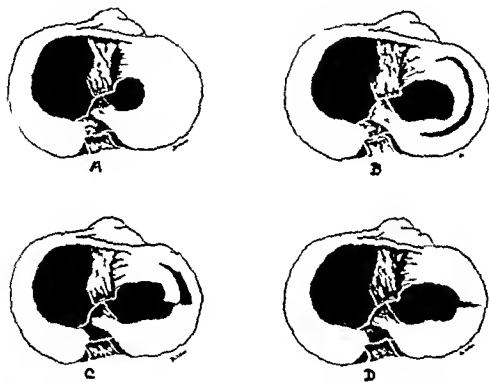


Fig 80—The more common lesions of the external semilunar cartilage A, Descoid cartilage B, Bucket handle tear C, Anterior tear D, Transverse tear

cartilages was one in five. In our series it was one in five, the usually accepted incidence is about one in seven (Fig 80). The lesion is the result of an adduction internal rotation force through a knee which is slightly flexed in weight bearing. Tenderness is found on the external aspect of the joint line at the site of cartilage injury. Bucket-handle tears with displacement of the fragment cause limitations of complete extension, and sometimes account for typical locking. Anterior horn lesions sometimes cause audible clicking as the joint is actively extended usually at 150 to 160 degrees of extension. Occasionally, injury to the external semilunar cartilage will present symptoms on the medial side of the joint. In such instances when a knee is opened and

no pathologic changes are found involving the internal cartilage the external cartilage should be explored for the possibility of injury. There are also a few cases especially in athletes when there is injury to both the internal and external cartilages. Careful history and examination will give a clue and the surgeon must be prepared to remove both cartilages when indicated. The results in such cases are satisfactory, we have had two such cases in a limited series.

*Surgical Technic for Removal of Semilunar Cartilages*—The usual careful asepsis must be rigidly enforced as in all joint surgery. The anesthetic may be of the surgeon's choice but spinal anesthesia in this usually young group is ideal. A tourniquet is of great advantage but the hazards of its use must be recognized. A pneumatic tourniquet, where the amount of constriction can be accurately determined is advised. Many incisions have been used. The author feels that an incision which will allow adequate exploration of the joint, and entrance

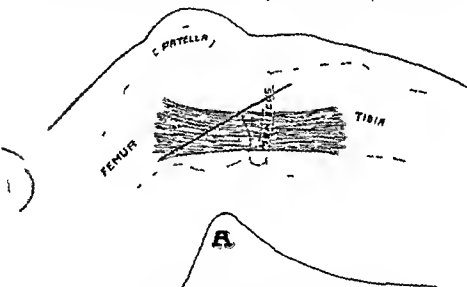


Fig. 81—The Bosworth incision. A Line of skin incision

into the posterior capsule without additional skin incision, is the one of choice. The *Bosworth's incision* fulfills the latter requirement (Fig. 81). It has been more used recently and has been found extremely useful, both for complete excision of the cartilage by use of the posterior capsule incision when indicated or when complete joint exposure is desired. The incision can be extended upwards and will allow for reflection of the patella as might be necessary if chondromalacia of the patella is encountered.

When the capsule and synovial membrane are opened the joint is inspected. The condition of the synovia, the anterior cruciate ligament, the articular surfaces of the femoral condyles and patella, the fat pad and that portion of the opposite cartilage which can be observed

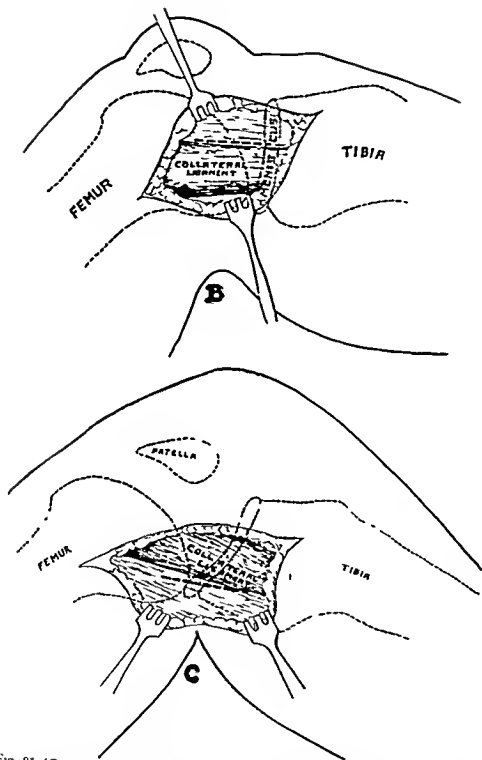


Fig 81 (Continued) —The Bosworth incision B, Dotted line shows line of an anterior capsule incision C, Dotted line shows line of posterior capsule incision should be carefully inspected and any abnormality noted in the operative report Attention is then directed to the affected cartilage The cartilage must be removed whether the split can be seen or not Local-

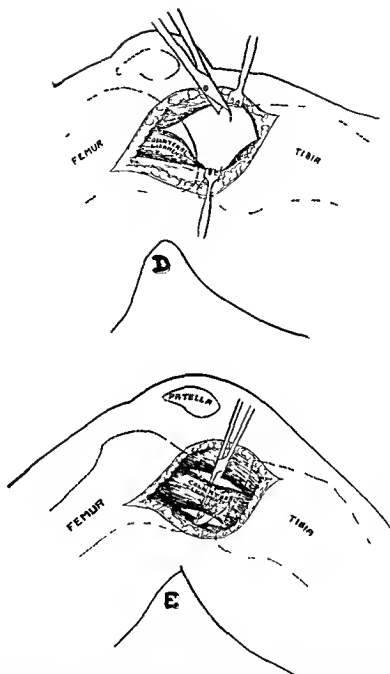


Fig 81 (Concluded) —The Bosworth incision *D* Detaching the semilunar cartilage at its anterior attachment *E* Passing the cartilage behind the internal lateral ligament to continue the complete excision of the semilunar cartilage.

ized tears or detachments of the posterior horn cannot be seen until removal of the cartilage is almost complete. In proceeding, the anterior horn is detached from the tibia. It is grasped then with a deep toothed clamp and drawn towards the center of the joint. With a retractor against the internal lateral ligament, the line of junction can be readily seen. The peripheral fibers of the attachment are cut by vertical strokes of a solid scalpel, the cartilage being pulled forward and across the joint until it slips across the intercondylar space. In certain cases, the posterior horn can then be seen and divided at its attachment, however, in a great number of cases, the cartilage will not completely deliver. The posterior skin flap is dissected posteriorly, care being taken to avoid the internal saphenous vein. The knee is flexed to a right angle, and a curved clamp passed inside the joint to a point posterior to the internal lateral ligament.

A second capsular incision is made in a longitudinal direction, and the joint opened in the posterior compartment. The cartilage is then passed through this opening, the dissection completed to its posterior attachment, and the entire cartilage removed. Closure of the posterior capsular incision is not necessary, as it closes when the knee is straightened. The anterior synovial membrane is closed loosely. When the posterior capsular incision is not used, we have found Chondler's method of puncturing through the medial suprapatellar pouch into the vastus medialis muscle to allow escape of the synovial effusion to be of advantage. The capsule is approximated with interrupted sutures of fine chromic catgut. The skin and subcutaneous tissues are closed. Large compressing dressings of either absorbent cotton or sheet wadding are applied with several Ace bandages as reinforcement, extending from the ankle to the groin. The tourniquet may be removed upon closure of the synovial membrane in order to obtain complete hemostasis.

*Postoperative Care*—In the Army it has been my practice to have each patient instructed in quadriceps exercises two or three days before surgery. After surgery, the limb is elevated and forty-eight hours postoperatively the quadriceps exercises are resumed under supervision. The quadriceps is contracted at least ten times every hour, and frequently more often. Morphine is necessary during the first two to three days for control of pain. The patient is kept in bed ten to fourteen days. The sutures are removed at the end of ten days, and active motion begun when comfortable, usually five to seven days postoperatively. Occasionally sharp rises in fever during the first forty-eight hours may be observed due to hemarthrosis. These rises will subside rapidly with aspiration and more rigid immobilization. Exercises under these circumstances are postponed until the temperature has returned to normal. At four or five weeks the patients are put on graduated quadriceps exercises which will be more fully explained later in this

article Many postoperative cartilage patients are ready for sedentary work in three to four weeks, and for more active endeavors in six weeks In the Army, because of the rigors of camp life, the usual disability is approximately twelve weeks before return to active duty

**Cysts of the Semilunar Cartilage**—Cysts of the semilunar cartilages are due to mucoid degeneration of the cartilage substance, and are usually the result of direct trauma to the meniscus, or indirectly of compression between the femur and the tibia The external cartilage is more commonly involved, the cystic area involving the peripheral part of the middle third of the cartilage

The cyst is multilocular and gives rise to a swelling beneath or just anterior to the external lateral ligament The patient complains of aching pain, but there is no locking, giving way or recurrent swelling The diagnosis is made by the location of the swelling, which can be seen and felt

Treatment is excision of the whole cyst and the cartilage from which it arises

#### DISTURBANCES OF THE COLLATERAL AND CRUCIATE LIGAMENTS

Much has been written on the ligamentous structures about the knee of the various mechanisms of Brantigan and Voshell<sup>1</sup> in review of these articles

is recommended to the surgeon who would handle knee injuries

In the Army relaxation of the ligamentous structures about the knee constitutes a marked disability, and it is a frequent cause for discharge from the service In review of a large number of cases it is readily apparent that the nature of the injury is not always appreciated and, as a result, the case is not properly treated It has been observed that ligamentous injuries, if properly treated, will respond with gratifying results This observation makes it mandatory that every knee injury be carefully evaluated at an early date in order to eliminate many permanent disabilities

**Mechanism of Injury to the Ligaments**—*The Internal Lateral Ligament*—This injury is seen most often in football and skiing accidents The same mechanism is observed as in injuries of the internal semilunar cartilage, i.e., flexion, abduction and internal rotation with the weight being borne on the foot of the affected side, and with the force applied to the knee

In consequence, from this force are First, the deep fibers of the internal lateral ligament, then, the anterior cruciate ligament, as it is stretched by the medial border of the lateral femoral condyle This type of injury often results also in a tear of the medial semilunar cartilage If a fracture of

the lateral tibial condyle occurs, usually the ligaments are spared. The above mechanism has been frequently observed in cases with lateral slipping of the patella. Following displacement of the patella, the continued force frequently results in serious injury to the supporting ligaments. It is advisable always to check for internal lateral ligament injury in cases where there has been transient displacement of the patella.

*The External Lateral Ligament*—Tears of the external lateral ligament are much more infrequent, and occur from a reversal of the above injury—the force being applied from the inner side of the knee with adduction, internal rotation and flexion while the foot is fixed. With this force there is, in sequence, tearing of the external lateral ligament, the anterior cruciate ligament and often the tendon of the popliteus muscle. Occasionally there may be associated injury to the common peroneal nerve.

*The Anterior Cruciate Ligament*—These injuries may occur as an isolated injury when, with the leg extended, a force is applied to the anterior aspect of the thigh, forcing the knee into hyperextension. The posterior capsule is stretched, and then rupture of the anterior cruciate ligament occurs, occasionally an avulsion of bone at its tibial origin may occur.

*The Posterior Cruciate Ligament*—With the knee flexed, forced posterior tibial displacement results in tearing of the posterior ligament. Usually the tear is at its tibial insertion, frequently with an avulsion of a small portion of bone, but it may occur at the femoral insertion.

The above mechanisms are described by Palmer,<sup>6</sup> and constitute the most common mechanisms of injury.

*Diagnosis of Internal Lateral Ligament Injuries*—The internal lateral ligament is the most commonly injured structure about the knee joint, and may be combined with other injuries. As mentioned before, in all cases of knee injury, especially in suspected trauma to the semilunar cartilage, evaluation of the internal lateral ligament must be made. Removal of the semilunar cartilage, even if damaged, will not correct an unstable knee.

*Clinical Symptoms*—Following injury, there is *pain* over the inner aspect of the joint at the site of injury. Frequently the pain is not immediately severe and the patient will continue with activity. The pain increases rapidly, usually after a short time. There is frequently *inability to extend the leg*, noticed more the next day, in contradistinction to the immediate locking of a torn cartilage. The findings are *tenderness* over the site of injury, i.e., the ligament rather than the anterior joint line as in cartilage injury. There is also *loss of complete extension* and a moderate to severe *synovitis*. Abduction of the knee causes pain over the torn ligament. In severe tears there is frequently



marked *spreading of the joint* when the leg is forcibly abducted. This positive abduction sign is of utmost importance, and should always be carefully checked. In marked relaxation of the ligament this sign can be easily elicited, however, in questionable cases the pain and spasm

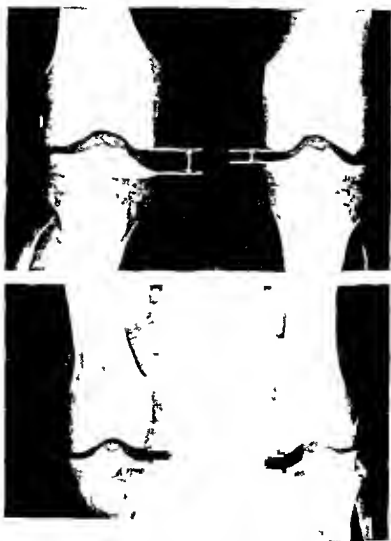


Fig. 82—X ray studies of tear of the internal lateral ligament showing positive abduction spread

may well prevent careful examination. In these cases it is highly recommended that the knee be examined under anesthesia, preferably sodium pentothal.

Palmer,<sup>6</sup> and Abbott, Saunders and others<sup>7</sup> advise that x ray

studies be carried out at this time. The knees are bound together and flexed slightly on a pillow, with the x-ray cassette under the pillow. The feet are then wedged apart with sand bags. Anteroposterior x-rays are taken to ascertain any difference in the joint space on the inner aspects of the knees (Fig. 82).

This positive x-ray study is of great value, and we have used it routinely where clinical examination was not conclusive.

Abbott, Saunders and others<sup>2</sup> feel that with an intact anterior cruciate ligament a knee in complete extension will not reveal a positive abduction sign, even with complete rupture of the internal lateral ligament but that, if the knee is slightly flexed, the sign will be positive. They likewise feel that a positive abduction rocking with the knee fully extend suggests a tear of the anterior cruciate ligament, along with tearing of the internal lateral ligament. When this test is positive in an extended knee, following an acute injury, they feel that it is an indication for surgical repair. *Hemarthrosis* is usually present in ligamentous injury and is a cause for pain. Aspiration of the knee joint is indicated for relief of pain which will facilitate examination and also to avoid later joint stiffness. A further aid in diagnosis is the use of *novocaine infiltration* over the tender area. With the relief of pain, the knee may show complete extension, thus aiding in the differential diagnosis of a cartilage injury. The presence of a positive drawer sign, i.e., increased anteroposterior motion, suggests cruciate ligament injury.

**Treatment**—1. **Conservative**—For minor strains, and those cases which show no evidence of severe separation of the joint surfaces on the abduction test, immobilization in a cylindrical cast for a period of two months with the knee in almost full extension, and with correction of the valgus deviation, is recommended. Hourly quadriceps exercise is essential during the period of immobilization, to be followed later by more intensive quadriceps training. On removal of the cast, a  $\frac{1}{4}$  inch wedge on the inner side of the heel is advisable.

2. **Operative**—In those cases where there is marked relaxation, signs of anterior cruciate ligament injury or internal cartilage injury, immediate surgical repair of the internal lateral ligament and, if necessary, excision of the internal semilunar cartilage is advised. Following surgical repair of the ligament the leg is immobilized in plaster for a period of eight to ten weeks. Emphasis is again placed on quadriceps exercises.

Late operative repair of the ligamentous structures has not proved satisfactory in most cases, and more has been gained by vigorous strengthening of the quadriceps. The exceptions are those markedly unstable knees which necessitate bracing, in which cases ligamentous repair may be attempted, although arthrodesis may ultimately be necessary.

**Injuries to the External Lateral Ligament**—The symptoms are similar

to those of the internal lateral ligament injuries, but the tenderness is over the outer aspect of the joint, most commonly at the fibular insertion of the ligament. Occasionally the peroneal nerve may be in

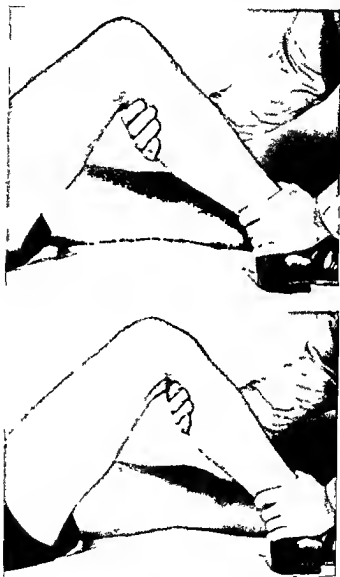


Fig 83—Showing a positive drawer sign for tear of the anterior cruciate ligament

involved with resultant sensory and motor loss. In external lateral ligament tears there is adduction rocking, and this sign can be confirmed with x-ray studies, using an adduction force rather than an abducting

force. The treatment is the same as for internal lateral ligament tears, except that the varus deviation is corrected and the shoe raise, when used, is placed on the outer side of the heel. The ligamentous tear may be associated with an avulsion fracture of the head of the fibula. Chronic relaxation of the external lateral ligament does not produce as much disability as that of the internal lateral ligament, because the outer side of the joint is well protected by the biceps femoris muscle and the iliotibial band.

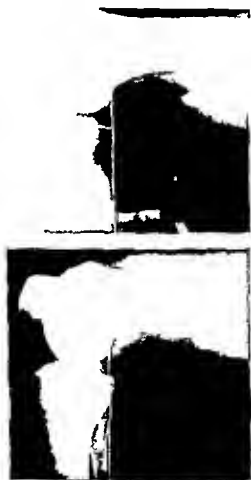


Fig 84—X ray study showing tibial excursion on femur in case of anterior cruciate ligament rupture (Same case as Fig 83)

The diagnosis of injury to these ligaments is obtained by a careful history as to the type of trauma and by the presence of synovial effusion, usually a hemarthrosis. In a rupture of either ligament the patient complains that the leg has "given way." The essential clinical finding is a positive drawer sign (Figs 83 and 84). With the knee flexed to a right angle, in tears of the cruciate ligament, there is abnormal mobility in the anterior direction. In those tears of the posterior cruciate

ligament the tibia can be displaced backward on the femur to an abnormal degree. This test should be made in comparison with the normal leg. Frequently after injury, there is considerable hemarthrosis and hamstring muscle spasm. To evaluate the findings carefully the knee should be aspirated and if spasm is still present the knee should be examined under anesthesia. X rays are essential as many cruciate ligament tears are associated with avulsion fractures.

*Treatment*—The treatment is the same whether the anterior or posterior cruciate ligament is involved. The joint should be immobilized in a plaster cast from the groin to the toes with the knee flexed 30 degrees. The head of the tibia should be pushed backwards in ruptures of the anterior cruciate ligament or pulled forward in ruptures of the posterior cruciate ligament. This immobilization should be continuous for three months. Throughout this immobilization quadriceps exercises should be diligently practiced and continued following removal of the plaster cast. In cases of unhealed ruptures of the cruciate ligaments many ingenious operative procedures have been devised to reconstruct the ligaments. Most of these make use of fascia lata to substitute for the ligaments. The usual result is stretching of the fascia with a poor final result. Persistent exercise of the quadriceps will give more gratifying results without the added trauma of surgery.

#### DISTURBANCES OF THE ARTICULAR CARTILAGES

*Osteochondritis Dissecans*—This condition occurs in young people and is characterized by a fragment of bone and overlying cartilage gradually sequestering from a point usually on the lateral aspect of the medial condyle of the femur in the intercondylar notch. The condition may occasionally occur involving the lateral femoral condyle or patella. The early symptoms are vague discomfort in the knee with occasional transitory synovitis and a slight loss of extension. The patient as a rule is not seen in this stage. As the disease progresses the fragment of bone and cartilage becomes free and the symptoms then are frequent transitory locking of the joint. Synovitis is more common when the body is loose.

*Diagnosis* may be suspected from the history of locking and the palpation of a loose body. A ray examination is of course essential (Figs. 85 and 86). The Holmblatt x ray view is of marked value in the early cases. This view shows the intercondylar notch and will frequently reveal the lesion before the body has become free in the joint space.

*Treatment*—The only treatment is surgical. If the diagnosis is made before complete sequestration the area of softened cartilage is completely resected along with the underlying bone which is found to be loosened. The defect in the femoral condyle is gently curetted. When

the body is loose in the joint, early surgery is advisable to avoid traumatic arthritis. The etiology of this condition is not fully known. Koenig<sup>7</sup> attributed it to the blockage in the end artery supplying this area on the internal condyle. Other authors attribute it to trauma alone, but this alone seems insufficient cause.

**Chondromalacia of the Patella.**—Chondromalacia of the patella is a disease characterized by a primary degeneration and fibrillation of the articular cartilage. It may occur as a primary disease, although probably it is the result of unrecognized trauma. It is frequently associated



Fig 85.



Fig 86

Fig 85—Osteochondritis dissecans of the medial femoral condyle with loose body

Fig 86—Large osteochondrotic defect of lateral femoral condyle

with other internal derangements of the knee. With the increasing frequency of this diagnosis in Army experience, the author feels that chondromalacia of the patella deserves a very prominent place in the discussion of internal derangements of the knee. A few cases have been seen with present findings of chondromalacia and a history of previous surgery, usually meniscectomy, without relief of symptoms (Fig. 87). After treatment for chondromalacia, the symptoms have been relieved. The history is one of chronic disability with general symptoms of internal derangements of the knee. There is usually pain in the region of the patella and transient synovitis after excessive exercise. The most

constant complaint is crepitus, which is often quite audible as the patella passes over the femoral condyles. The onset of symptoms varies in the author's experience. It is frequently after direct trauma to the knee. It is almost a constant accompaniment to a subluxating patella. In one case it followed recovery of a fracture to the anterior tibial spine. The crepitus can best be elicited with the patient in the supine position, with the thigh and knee fully flexed, and then having the patient extend the knee actively. The crepitus can be palpated and



Fig. 87—Chondromalacia of the patella

frequently is audible. The x ray is of little value except for differential diagnosis.

*Treatment*—When the symptoms are severe enough to interfere seriously with normal activities, surgery is indicated. Adequate exposure to evert the patella is used. A chondrectomy, in which the fibrillated cartilage is excised, may be done, or a complete patellectomy should be performed if the disease is so extensive as to make simple chondrectomy inadvisable.

The pathologic changes are limited to the fibrillation of the cartilaginous surface of the patella. The underlying bone shows no appre-

able change. If the disease is of long standing there may be mirror-like changes on the adjacent cartilage of the femoral condyles. This involved cartilage should also be removed.

Postoperative care is similar to that described for the removal of the meniscal cartilages. Quadriceps drilling is again of utmost importance.

### DISLOCATION OF THE PATELLA

There are essentially three types of dislocation of the patella to be considered, although the direction of the displacement of the patella is always the same, viz., to the outer or lateral side of the knee. These three types are (1) congenital, (2) acute and (3) traumatic, recurrent. Congenital Dislocation of the Patella—The congenital type of slipping patella occurs in patients without history of injury, and upon examination the patella is found to ride over the lateral femoral condyle whenever the knee is flexed. In such cases there is frequently a long, infrapatellar ligament associated with an underdeveloped lateral femoral condyle. A tendency to genu valgum frequently is present. There is also relaxation of the mesial or internal portion of the capsule of the knee. One or more of these congenital anomalies may be found in any given case.

*Surgical repair* is the only method of treatment. Great care in evaluation of associated deformity is essential. In general the most adequate correction results from plication of the internal capsule, combined with patellectomy or tibial tubercle transplant. It may be, in certain cases, necessary to elevate the external condyle or to correct the knock knee deformity by osteotomy.

Traumatic Dislocation of the Patella—The second type, or traumatic dislocation of the patella, usually occurs when the tibia is abducted and externally rotated, associated with a forceful contraction of the quadriceps muscle, thus producing the dislocation. A shearing force striking the patella from the inner aspect may also produce the dislocation. Frequently these patients have factors predisposing to their dislocation, such as lax joint capsules, or knock knee tendencies. When such dislocations occur, the patella frequently reduces spontaneously as the knee is extended, or may be reduced by a bystander. Clinical findings often are meager after reduction, but usually include a *synovitis* and *tenderness* over the inner margin of the patella. *Differential diagnosis* from a cartilage injury may be difficult, necessitating a careful elicitation of the history and a check for laxity of the patella. In our experience associated tears of the internal lateral ligament and occasionally of the anterior cruciate ligament are not uncommon.

The treatment of a traumatic dislocation of the patella in the acute case consists of *immobilization in a cylindrical cast*, maintaining the knee in extension for a period of two months. Again, great care must



be observed to maintain the quadriceps muscle strength by appropriate exercises

*Recurrent Dislocation of the Patella*—The third type to be described that of recurrent dislocation of the patella, is usually seen in patients with uncorrected or neglected weakness of the vastus internus muscle or in those cases with a rather pronounced knock knee deformity. In such patients a sudden contracture of the quadriceps muscle with the knee in a flexed position directs a lateral pull on the patella resulting in dislocation. In all cases of recurrent dislocation of any standing we have found an associated chondromalacia of the patella. It is well known that such cases lead to a marked arthritis of the patellofemoral joint.

As regards treatment of congenital dislocation should be examined

should be instituted for this also as described in the discussion of this condition. Simple excision of the patella is not advisable for slipping patella without other corrective measures as there will be a persistence of the slipping of the quadriceps tendon even as there was of the patella.

#### DISTURBANCES OF THE FAT PADS

Occasionally there may be changes in the infrapatellar fat pads which result in symptoms suggestive of internal derangement. Hypertrophy of the pads with elongations which may become nipped between the femoral condyles and the tibial surfaces leading to recurrences of pain and simulated lockings are occasionally seen. The diagnosis can only be made by surgery and the treatment is partial or complete resection of the fat pad. This condition is not common and while frequently described it is probable that this accounts for very few cases of knee disability.

#### OTHER DISTURBANCES OF THE KNEE SIMULATING INTERNAL DERANGEMENTS

*Synovitis*—Acute or chronic synovitis may at times give symptoms similar to internal derangements. In the presence of joint effusion a careful history and physical examination will aid in the differential diagnosis.

*Fractures*—Fractures of the tibial spines, minor fractures of the patella and those fractures involving the tibial plateaus or femoral condyles may all simulate internal derangements. The x ray will reveal the true nature of the injury and careful examination will aid in ruling out other associated ligamentous or cartilage damage.

*Pellegrini Stieda's Disease*—Strain of the internal lateral ligament may result in a calcification in the region of the ligament. The symptoms are those of a chronic internal lateral ligament strain. There is pain

in the inner aspect of the knee, most marked after use, accompanied by occasional mild swelling. There is usually no instability. X-ray studies reveal the calcified deposit. The treatment in early cases is immobilization of the leg in plaster for a period of three to six weeks, followed by a one-quarter inch raise on the inner side of the heel to avoid further strain. When the calcification is extensive and the symptoms are resistant to conservative treatment, surgical excision of the calcification may be undertaken. Care should be observed to avoid surgery, however, until all conservative measures have failed.

**Osteochondromatosis**—Osteochondromatosis is a disease characterized by the presence within the knee joint of multiple osteocartilaginous loose bodies. The etiology of this condition remains obscure, although the synovial origin of the loose bodies is generally accepted, and often at surgery some of the bodies are found attached to the synovium. No cases of this disease are described in our series. The reason for this is apparent as the history of swelling and locking of the knee, together with x-ray examinations, eliminates such individuals before Army induction.

The treatment of this condition is entirely surgical, and at time of operation necessitates a most careful exploration of the joint. An x-ray check at time of surgery is a valuable adjunct. Total synovectomy is frequently indicated in addition to removal of the loose bodies.

#### QUADRICEPS TRAINING

In all cases of knee injury there is an unusually rapid atrophy of the quadriceps muscle. As has been previously pointed out, this muscle is the principal support in preventing rotation of the knee in all its positions except complete extension. In every case of knee injury, except open wounds, recurrent hemorrhage or possible infection, exercises to strengthen the quadriceps should be given at least five minutes out of every hour daily. The exercise should be active. Massage or electric stimulation is passive, and will not restore voluntary control. It is our practice to supervise quadriceps exercises two or three days prior to surgery so that the patient learns how to actively contract his muscle. The exercises are resumed within forty-eight hours after surgery, or as soon as postoperative reaction will permit. The exercises are non-weight bearing. When all synovitis has subsided, and motion is well on its way to normal return, the patient is then put on a definite program of increased muscle exercise. This is obtained by a method used by weight lifters. A metal shoe and bar, on which weights can be applied, is attached to the affected leg, and the patient, in the sitting position, is made to fully extend the leg and return it to the flexed position. These weights are increased as power of the thigh will allow. (Fig 88)



Fig 88—Advanced active resistant quadriceps exercise

Cases of unstable knees, which previously had had conventional physiotherapy for a period of three to four months without benefit, when placed on this described program showed rapid increase in thigh circumference and equally rapid diminution of symptoms. The usual

postoperative "knee cartilage" case will show approximately normal thigh measurements after two to four weeks' work with these weights.

The importance of careful attention to quadriceps redevelopment cannot be overstressed, and many cases which have defied previous treatment will show marked improvement when the thigh is strong.

### SUMMARY

1 'Internal derangement of the knee' is a general term and should not be used as a diagnosis.

2 An accurate diagnosis of knee injury is indispensable to proper treatment.

3 Immediate recognition of acute ligamentous injury of the knee is of prime importance. Only proper early treatment will prevent permanent disability.

4 Lesions of the posterior portions of the semilunar cartilages cannot be excluded by surgical inspection of the knee joint. When clinical findings indicate the presence of such a lesion, a complete excision of the cartilage is indicated, whether or not the lesion can be seen at time of surgery.

5 Chondromalacia of the patella is a definite clinical entity and is of more frequent occurrence than is generally recognized.

6 Adequate quadriceps power is an absolute necessity to the normal functioning of the knee. Proper supervision and training of the quadriceps muscle in all cases is advised. In our experience, a method used by weight lifters, with focal attention to the muscle, and against increasing resistance, has given results superior to those obtained from conventional physiotherapy.

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## MANAGEMENT OF LESIONS OF THE SUBTALAR JOINT

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### SUBTALAR LESIONS DUE TO STATIC CHANGES

THE most common lesion of the subtalar joint is a displacement of the calcaneus laterally, or a valgus deformity, due to an imbalance between the demand made upon the foot and the capacity of the foot to carry out the work required of it. This is the ordinary valgus deformity seen in pes valgoplanus as a result of prolonged foot strain. The retention of this position alters the relationship of the two articular surfaces of the subtalar joint. This position will cause a strain on the ligaments in this area, and set up an inflammation within the articulation itself. The inflammation of the joint, if prolonged, will result in arthritic changes, so called chronic hypertrophic arthritis (arthrosis).

**Principle of Treatment**—The treatment first consists in a *realignment of the articulation*. This is done by bringing the heel into varus. It is essential, however, that the normal relationship of the heel to the interior part of the foot be retained. If the anterior part of the foot is brought into supination while bringing the heel into varus, there will be a tendency for fixation of the supinated position. Bringing the head of the first metatarsal bone onto the floor would force the heel into valgus, so that raising the inner side of the anterior part of the foot would tend to counteract the effect of bringing the heel into varus. It is therefore necessary to bring the heel into varus, and at the same time lower the inner side of the anterior part of the foot so that the medial side of the foot rests on a lower plane than the outer side. The head of the first metatarsal bone is then lower than the heads of the second and third metatarsal bones. With the anterior part of the foot in pronation and the heel in varus position, the normal relationship of the articular surfaces of the subtalar joint will be re established.

### Case Report

The first case to be presented is that of a 6 year old boy who came in complaining of trouble with his left ankle. The heel turned out and the parents also noticed that he had a complete flatfoot (Fig 89). He walked with outward rotation of the foot and also had a valgus at the knees. There was some valgus of the knee and heel on the right side but it was much worse on the left. The calcaneus turned out at the subtalar joint and the head of the first metatarsal

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bone was displaced upward. There was a complete loss of the longitudinal arch and no anterior or transverse arch. The foot was free, however. As I took this heel in my hand and brought it over into varus, this movement was in the subtalar joint. As soon as weight bearing was placed on the foot the heel would go back into valgus. It was my object, therefore, to bring the heel into varus and hold it there, and then train the foot so that the heel would stay in this position with weight bearing.



Fig. 89—Flatfoot in child with valgus at the subtalar joint, two views

**Treatment with Adhesive Tape**—The most practical method of bringing the heel into varus is to raise the inner side of the heel of the shoe. In this boy, I first held the heel over by means of adhesive strapping. Compound tincture of benzoin was used first to paint the skin, covering the outer side of the heel below the malleolus, the bottom of the heel, the inner side of the foot and leg up over the middle third of the leg. Then the foot was held in position by means of a 1-inch webbing band about a yard long. The child took one end of the webbing in each hand, and with the loop over the anterior part of the foot, the foot was brought into supination with the heel in varus. With the patient sitting on a table and the legs hanging over the side, it is easy to apply the tape to the heel. The 1-inch adhesive tape is started at the outer side of the heel and brought around under the heel, to be fastened up on the medial side of the leg. The next strip of tape overlaps the previous one, and is swung around in the same way. This is repeated until the entire skin of the medial side of the leg is covered. Two cross strips are run over the upper ends of the tape on the medial side of the leg, two cross strips just above the medial malleolus and two cross strips below the medial malleolus. On the outer side of the heel the tape is also reinforced by transverse strips. This holds the heel in varus. Since the foot is pliable and there is nothing to hold the

anterior part of the foot in supination, it will go back into normal position. As the boy stands with the adhesive strapping applied the heel is in varus and there is a normal relationship of the subtalar articulation, the heel is in supination and you know that the articular surfaces of the subtalar joint are in normal position. The longitudinal arch has been re-established.

**Treatment with Pads in Shoes**—To hold this position further a pad was placed in the shoe. The pad is formed of resilient felt, which is soft enough to be comfortable and yet firm enough so that it holds the

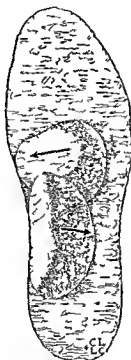


Fig 90—Felt pads to correct valgus at the subtalar joint (From Hauser, 'Diseases of the Foot')

position of the foot. The pad is shaped by means of a sharp knife to form an inclined plane, and is then placed beneath the longitudinal arch with the height of the inclined plane on the medial side of the foot (Fig 90). This tends to bring the heel into varus. To further insure that the inner side of the anterior part of the foot will rest on the ground, a second pad is placed behind the heads of the metatarsal bones. This pad also is shaped from the felt to form an inclined plane. The incline, however, is directed from the outer side of the foot toward the medial side. Since the head of the first metatarsal bone normally should rest on the floor, this pad must extend only to beneath

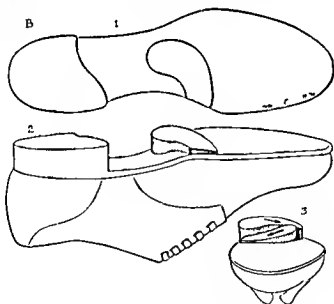
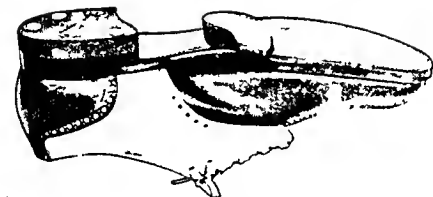


Fig 91—A, Corrective shoes used to alter the valgus at the subtalar joint B, The inclined plane of heel corrects the valgus while the inclined plane of the bar retains normal position of the anterior part of the foot (From Hauser, Diseases of the Foot')



the fourth metatarsal bone. Since the fourth third and second metatarsal bones are raised higher than the first and fifth, the *transverse* arch is definitely re-established, and with the head of the first metatarsal bone down on the floor and the heel in varus, there is a very definite longitudinal arch.

**Treatment with Corrective Shoes**—With the normal position of the foot restored, the next problem was to re-establish proper use in this position. Since the normal use of the foot is walking, if we could get this boy to walk with the foot held in this position we would be dealing with the most practical type of exercise. We could not continue the use of the tape over a prolonged period of time, because of irritation of the skin. The shoe that he wore when he came in had a stiff shank, therefore he could not walk in a normal manner. To obtain more efficient correction we took the metal shank out of that shoe and then raised the inner side of the heel of the shoe  $\frac{1}{4}$  inch to throw the heel into varus. To be sure again that the inner side of the anterior part of the foot would be lower than the outer side, we used a transverse bar on the sole of the shoe, to take the place of the anterior pad inside the shoe. This bar is constructed so that it forms an inclined plane which is higher on the outer side than on the medial side. Further more, the bar ends behind the head of the fourth metatarsal bone. In this way the shoe will bring about the correction which we obtained by means of the strapping and the pads (Fig 91).

**Normal Gait as Corrective Exercise**—With this type of shoe the child had to learn to use the foot normally. We first let him walk as he had been accustomed to. He walked with both feet turned out, his body sagged and he shifted his weight from one foot to the other without any propulsive force coming from the foot itself. This was the typical flatfoot gait. We taught him to pull himself as tall as possible, to turn the toes in so that the feet pointed straight ahead and to place the heel on the ground with the foot in dorsiflexion. Holding this dorsiflexed position the body weight rolled over the heel. In this position with the foot dorsiflexed and the knee held rigid, a long lever is formed, one arm of the lever being the foot and the other the lower extremity. As he held this position and rolled he got a leverage action which enabled him to walk with the minimum amount of effort (Fig 92). He rolled all the way over the heel and gradually over the outer side of the foot and then pushed off the ground the very last thing with the toes. In so doing the weight was transferred from the heel over the outer side of the foot and then across over to the great toe. With the supinated heel and the transverse bar raised on the outer side, this movement was easily executed. Since he had never been accustomed to walk this way, I advised that he only practice this gait for a period of five minutes at a time to start, but that he do it ten times a day increasing the time gradually. Otherwise there would be a tendency

not to use the corrections, but to walk with his old flatfoot gait, or if he tried to walk correctly for too long a time at first he would be certain to develop muscular strain which might discourage his continuing with the treatment.

**Conclusions**—By practicing this gait the boy is now able to walk in this manner automatically and has formed a definite habit, so that he can carry out the correct exercise without effort. The very fact that the foot is in normal position as it is seen now, and that the normal subtalar relationship has been re-established, has relieved the symptoms.



Fig 97—Illustration to demonstrate normal gait which is used for corrective exercise (From Hauser, *Diseases of the Foot*)

of which he complained, and will also prevent any recurrence or further development of serious trouble at the subtalar joint. Because of his continuous use of the articulation in normal position, we are assured there will be no recurrence of the subtalar disorder.

#### SUBTALAR LESIONS DUE TO ANTERIOR POLIOMYELITIS

The instability at the subtalar joint due to anterior poliomyelitis will cause inability to walk without braces and give rise to the most severe type of pes valgoplanus. If this condition is allowed to continue, the altered position of the heel will influence the knee so that there is also

a genu valgum present. In addition, when the two surfaces of the subtalar joint are no longer in normal relationship there is an increase of friction rub which will ultimately lead to arthritic changes. The restoration of the normal relationship of this articulation soon after the occurrence of the poliomyelitis is always simple, but if the changed position is allowed to remain then contractures are acquired which prevent the normal replacement of the heel.

### Case Report

This 12 year old girl came for examination because of an instability of the right foot. She had anterior poliomyelitis when she was  $1\frac{1}{2}$  years old, and it affected the right lower extremity. At first the limb was completely paralyzed, but gradually she regained some power. The recovery was more rapid at first, and the strength increased with use but the strength at the ankle never returned and she was not able to get about without the use of a brace.

**Diagnosis**—There was shortening of the right extremity with atrophy. The ankle joint was flail. There was a flaccid paralysis of the muscles controlling the foot. The quadriceps and flexors of the knee had good strength and showed but slight weakness. The patellar and Achilles reflexes were absent on the right. We had, therefore, a diagnosis of residual anterior poliomyelitis with an instability of the right ankle joint, which required a brace to enable the child to walk.

**Principle of Treatment**—In this instance, bringing the foot into normal position could easily be accomplished but there were no normal structures to hold it there so that the patient had to use a brace. We would have to obtain stability in some other way, in order to get rid of the brace. In this case it was necessary to do an *arthrodesis of the subtalar articulation*, to eliminate the lateral movement which caused the instability. Since the foot can only be inverted or everted, this implies that the movement of inversion would include bringing the heel into varus with supination and adduction of the anterior part of the foot, while eversion would mean that the heel is brought into valgus with abduction and pronation. Therefore, the movement at the subtalar articulation is always associated with movement at the talonavicular and astragalocuboid articulations. If the heel alone were fused then the talonavicular and calcaneocuboid articulations would receive abnormal strain and give rise to symptoms. To increase the stability and prevent the future development of arthritic changes it was advisable to fuse the talonavicular and the calcaneocuboid articulations at the same time that the subtalar joint was fused. To obtain this fixation the fusion operation was carried out.

**Operative Treatment**—An incision about 1 inch in length was made over the anterior lateral surface of the foot below the malleolus. A Martin bandage was used. The fat pad was dissected out cleanly. The astragalonavicular articulation was exposed and the joint cartilage

was entirely removed. The astragalocuboid articulation was then exposed and the cartilage removed. The subastragaloid joint was then obliterated. The astragalus at the navicular contact was crushed by means of a chisel. The foot was then put in proper alignment with the raw bone edges coming in contact. The wound was closed and a



Fig 93—End result after manipulation and fusion. *Upper*, Range of motion *Lower*, Shows improved appearance with stability.

plaster-of-paris cast was applied with the foot held in the position of choice.

The patient had an uneventful postoperative course. The wound was dressed on the sixth day through a window in the cast. There was old blood in the dressing and the wound was moist with serum. On the ninth day the sutures were removed. The wound healed, and on the

twenty-sixth postoperative day the cast was changed and the patient discharged from the hospital. The fifth week after operation weight bearing was permitted in the cast. The cast was replaced at which time the foot was found to be in excellent position and the arthrodesis was firm. We allowed the child to walk in the cast for three months. I could possibly have used the cast a little less if we had made a form fitting brace, but I felt it was safer to hold absolute fixation, and much more practical than trying to find a brace in the time that it was required.

**Conclusions**—The cast was released gradually and the patient, as you see her before you, walks with a stable firm ankle, with no pain and without the use of a brace (Fig. 93).

#### SUBTALAR LESION DUE TO FRACTURE OF THE CALCANEUS

A fracture of the calcaneus with the exception of the beak type of fracture, involves the subtalar joint. The treatment, as in all fractures, consists in reduction, fixation and re-establishment of normal function. The reduction may be carried out under local anesthesia or under general anesthesia. With the knee flexed and the foot in plantar flexion to relax the tendo achillis the fracture can be reduced manually. A compression that causes a locking of the fragments and a widening of the bones can be reduced by means of a Bohler compressor which consists of two kidney shaped metal pads that can be screwed together to forcefully compress the heel. After reduction, fixation is best retained by a form fitting plaster of paris cast. Occasionally a severe case may require skeletal traction.

**The Problem of Rehabilitation in Fractures of the Calcaneus**—More important than the reduction and fixation in my opinion is the problem of rehabilitation. Since the foot is put up in equinus there is also a tendency to contraction of the posterior group of muscles. If the heel is left in valgus there is certain to be a valgus contracture with a painful foot. If the foot is brought into supination even though the heel is in varus the anterior part of the foot becomes fixed in supination (Fig. 94). A fixed supinated position will force the heel into valgus with weight bearing. As soon as union occurs usually a period of about six weeks it is necessary to correct the equinus position of the foot and bring the foot about to a right angle and also to be sure that the heel is in varus while the head of the first metatarsal bone is on a lower plane than the head of the fifth metatarsal bone.

Statistics of large clinics as well as of insurance companies show that the prognosis of fracture of the calcaneus in the past has been extremely poor. According to some statistics the best result that could be hoped for is a 10 per cent disability, and the poor results go as high as 80 per cent disability for the injured limb. In all cases that have

been analyzed, the disability was the result of pain in the heel, and this pain was associated with muscle spasm and valgus deformity of the heel. The x-rays showed articular changes in the subtalar joint. Since the pain was believed to be due to the arthritic changes in this joint, the recognized treatment was to fuse the articulation. Many surgeons have felt that since such a high percentage of these cases developed arthritic changes later, it was advisable to fuse all calcaneus fractures that involved the joint as early as possible, the assumption being that they were going to give trouble, therefore it was advisable to fuse them at once and thus decrease the hospitalization period as

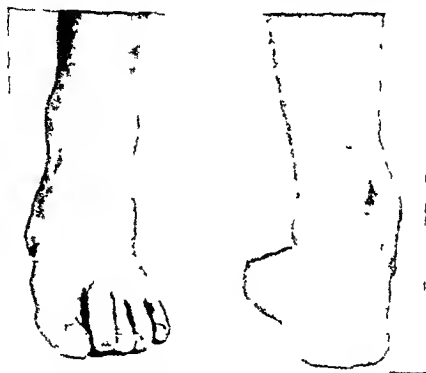


Fig 94—Fixed supination resulting in valgus of the heel (From Hauser, "Diseases of the Foot.")

well as the period of disability. The fact has been overlooked that all of the fractures of the calcaneus that give trouble have a valgus deformity, the more trouble they have the more severe is the deformity, and the most acute cases have a peroneal muscle spasm. In the cases where there were no arthritic changes visible by x ray, it was assumed that the pain was due to the fracture into the joint. There still were some cases in which the fracture was not into the joint and there were no articular changes by x ray, and yet there was extreme pain. For these no explanation was offered. The assumption that if there were arthritic changes present these arthritic changes caused the disability was permitted to go unchallenged.

My experience has been that every case of fracture of the calcaneus that is in valgus position gives rise to pain with weight bearing. Likewise in every case in which normal position at the subtalar articulation is re-established and the anterior part of the foot is in normal position and normal function is possible no symptoms are present. From my experience with these fractures I have concluded that the arthritic changes are not so much a result of fracture within the joint as of an altered relationship of the subtalar joint which gives rise to irritation and inflammatory reaction and ultimately arthritic changes. Cases in which there were fractures within the joint and the normal position was established after the fracture healed and resulted in complete re-establishment of function without pain whereas fractures that did not involve the joint but in which the position of the articular surfaces of the subtalar joint was altered gave rise to the typical pain seen in the fracture of the calcaneus. Furthermore a fusion of the subtalar articulation in the valgus position did not give relief of symptoms but left a persistence of pain while old cases which had been neglected and showed arthritic change were relieved by restoring the normal relationship at the subtalar articulation.

#### Case Report of Fracture into the Subtalar Articulation with Complete Recovery

The first case is that of a young man who sustained a fracture of the calcaneus which went into the talocalcaneal joint. On November 15, 1939, he fell 20 to 25 feet landing on his right heel.

**Treatment**—A temporary splint was applied immediately after the injury and he was sent to the hospital twenty-four hours later. The fracture was reduced and a plaster of Paris cast was applied. Three weeks later a form-fitting cast was applied directly to the skin and the patient was permitted to go home in another week. A caliper was applied to the cast but no weight bearing was permitted until six weeks after the fracture. He remained in the walking cast for eight weeks. When the cast was removed an Unna paste boot was applied and corrective shoes started. The heel of the shoe was supinated  $\frac{1}{4}$  inch plus. A second Unna paste boot was applied after two weeks and worn for two more weeks. Then the Unna paste boot was removed and a Tetra bandage applied. The patient continued with the corrective shoes and corrective gait and returned to work three months after the fracture. The x-ray shows the fracture within the joint.

**Discussion of Case**—According to the accepted conception this man would have a permanent disability and therefore it might be advisable to fuse, but as you see, he had an uneventful recovery and is able to carry out his normal occupation without return of symptoms.

### Case Report of Fracture without Involvement of Subtalar Joint, with Poor Result Until Statics Corrected

The second case is that of a man who sustained a fracture of the calcaneus at the age of 41 in June, 1939. I first saw him six months later. He had fallen from a height of 10 feet and was taken immediately to a hospital where the



Fig 95.—Fracture of the calcaneus, subtalar joint not involved, with persistence of pain. *Upper*, With persistence of pain. *Lower*, Correction of valgus with relief of pain.

fracture was reduced. The fracture was said not to be through the joint (Fig. 95). He was in cast eight weeks and this was followed by physical therapy.

When he came to me he was still unable to return to his regular work as an electrician. He had previously been advised by the attending surgeon to have a fusion operation, and he was then referred to me for further treatment.

**Diagnosis.**—Examination showed a valgus of the heel with weight-bearing, and the patient complained of pain beneath the lateral malleo-



lus There was swelling, tenderness and slight discoloration in this area. The patient had a spread of the anterior part of the foot and the head of the first metatarsal bone was displaced dorsally. Diagnosis was made of a fixed valgus deformity of the heel following a fracture of the calcaneus.

**Treatment**—The foot was in a varus position, and this position was maintained. The tape was started below the middle third of the leg on the medial side. The strapping was reinforced after three days. Corrective shoes were then started, with the heel raised  $\frac{1}{4}$  inch on the inner side and the bar raised  $\frac{3}{16}$  inch on the outer side. Novocaine was injected below the lateral malleolus and this relaxed the peroneal spasm so that further correction was obtained with the restrapping. The strapping was continued for six weeks, being replaced at intervals of about every seven days. The supination correction of the heel of the shoe was then increased from  $\frac{1}{4}$  inch to  $\frac{3}{8}$  inch. When the strapping was removed a Tetra bandage was applied in an attempt to force the heel further into varus. The patient returned to work five months after the treatment was started. He continued to work in his corrective shoes. It is now about five years since he was first seen. He has no symptoms, is able to do all his work and has made a complete recovery.

**Conclusions**—This case shows rather convincingly that the symptoms were due to the altered position of the subtalar joint rather than to the fracture, even though the calcaneus showed some exostosis on the lateral side which was said to be causing the pain. The original surgeon had in mind removing the exostosis and fusing the subtalar joint. However, by bringing the heel into varus and re-establishing normal position at the subtalar joint, function was restored. The continuous use of the foot in this position brought about normal strength so that the patient is able to carry out his usual work without any tendency toward recurrence of his symptoms.

#### Case Report of Fracture into Subtalar Joint with Excellent Reduction but Persistence of Pain

The third case is a man who came to me nine months after his injury with a fracture of the calcaneus. There was pain in the heel constantly, even when resting, but the pain was so severe with weight bearing that he was unable to carry out any gainful occupation. He originally fell 17 feet while at work and following his fracture the position by x ray was said to be good. A plaster-of-paris cast was applied and he was in cast for eight weeks without weight bearing. After removal of the cast the foot was painful and swollen and the pain and swelling increased with weight bearing.

**Diagnosis**—Examination revealed a supination of the anterior part of the foot, which was fixed. The patient also had a hallux valgus.

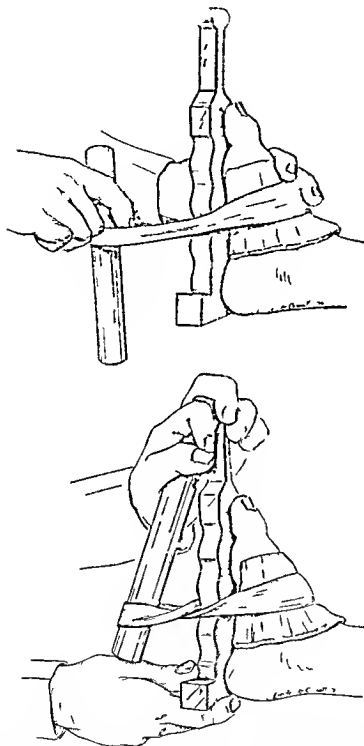


Fig 96—Application of Haglund footboard. The loop is screwed down in the form of a Spanish windlass. The board fastened to the foot permits leverage to correct the deformity. (From Hauser, 'Diseases of the Foot')

With weight bearing there was an absence of both the longitudinal and transverse arches, and the heel went into valgus. It was impossible

to bring the heel into varus and hold it there while trying to bring the head of the first metatarsal bone down so that it was lower than the head of the fifth

**Treatment.**—I advised manipulative correction under general anesthesia, which was carried out. The Haglund footboard was used to bring the foot into dorsiflexion since there was some shortening of the tendo achillis. The heel was brought into varus by means of the Haglund footboard, using the lateral leverage on the board (Fig. 96). The Thomas wrench was applied to the heel to force the heel into an



Fig 97—Special wrench and two views showing its application for correction of the supination of the anterior part of the foot. (From Hauser, "Diseases of the Foot")

overcorrected varus position. The anterior part of the foot was corrected by means of a special wrench (Fig 97). The wrench was applied with leverage force exerted to bring the head of the first metatarsal bone plantarward, so that the medial side of the anterior part of the foot was lower than the lateral side. A cast was applied, holding the heel in varus and the head of the first metatarsal bone plantarward, molding the longitudinal and transverse arches within the cast. The convalescence was unevenful. The patient was able to walk on the cast after two days, and the cast was on for a period of six weeks. This cast was then replaced by an Unna paste boot which was worn

or two weeks, and while he was wearing the boot the corrective shoes were started. The inner side of the heel of the shoe was raised  $\frac{1}{4}$  inch and the outer side of the transverse bar was raised  $\frac{5}{16}$  inch. He was then taught to walk with the heel-and-toe gait. He carried this out and was able to go back to work after three weeks. He has now been working for a period of about four years. As seen today, he has no pain, he is able to work and can stand on his feet and walk without trouble, but with heavy lifting he still has some pain in the subtalar area.

**Conclusions.**—This is a case of a man who had a fracture within the joint. It was a compensation case and was said to have been a perfect education, and yet he had total disability until correction of the altered position of the subtalar joint was obtained. He was referred to me for a fusion operation, but before fusing it was necessary to re-establish normal position of the foot. However, as soon as normal position was re-established it was no longer necessary to fuse, since he had relief of his symptoms. He, of course, would not consider any surgery for this foot at the present time.

#### Case Report of Subtalar Fusion with Persistence of Pain

This last patient is a man who had a fracture of the calcaneus in 1934. He was treated by means of manipulation and cast and the result was a painful heel. The pain was on the outer side of the ankle and the x-ray showed some over-



Fig. 98—Subtalar fusion in valgus position, with persistent pain

growth in this area. An operation was carried out and the exostosis was removed. He had had two other operations which were said to be of a similar type. removal of excessive overgrowth on the lateral side of the calcaneus. When I saw him he had an excellent fusion of the subtalar articulation (Fig 98). He complained of the same pain he had had ever since the fracture. The pain was on the outer side of the ankle and also over the front part of the ankle. The heel was in valgus and the peroneal muscles were in spasm. There was a supination grade III on a basis of I to IV in the anterior part of the foot and there were flexion contractures of the toes.

**Diagnosis**—This patient offered a very difficult problem since the foot was fused in the valgus position and there were symptoms which caused a total disability of this foot. The thought arose that the only way it could be corrected would be to do an osteotomy through the subtalar articulation and correct the valgus deformity. This is a rather formidable procedure in a man who has had a good deal of surgical treatment and a great many contractures already present. He had some shortening of the tendo achillis and a severe supination contracture as well as contracture of the toes. The supination contracture was such that he walked on the outside of his foot and the contracture of the toes caused friction rub on the dorsa of the toes. Before doing an osteotomy it would be necessary in any case to correct the supination deformity and the contracture of the toes as well as the short Achilles tendon.

**Treatment**—By means of the Haglund footboard under general anesthesia the foot was manipulated and the toes were stretched and the tendo achillis was stretched and some correction was taken of the supination. Force was also exerted against the valgus position of the heel. The Thomas wrench was applied to the heel and some correction was obtained. I realized of course that there was a fusion of the subtalar joint and that what correction was obtained at the ankle joint was by stretching the ligaments but I preferred the stretching of the ligaments at the ankle joint to retention of the valgus position. A cast was then applied and the patient was allowed to walk in the cast. For the first two days there was some pain and then he was able to walk with comfort.

This same type of manipulation was repeated at the end of three weeks and further correction was obtained. The anterior part of the foot was in better position and slight improvement in position was gained at the heel. Again at the end of four weeks the manipulation was repeated. This time definite improvement was obtained and a cast was applied. The patient was now able to walk great distances in the cast in fact he went rabbit hunting with the cast on. When the cast was changed again as much correction was obtained as was possible by means of manipulation without anesthetic.

This correction was repeated at intervals of about four weeks and in all the patient had seven casts. When the last cast was removed an

enna paste boot was applied to prevent recurrence of the swelling, and the corrective shoes were started. The heel was raised  $\frac{1}{4}$  inch on the inner side and the transverse bar was raised  $\frac{1}{4}$  inch on the outer side. He was able to return to work as a carpenter after three months. He continued to work until the war broke out, when he was drafted into the Army and passed his examination, and he has been in the service ever since.

**Conclusions**—This case shows that it is not the arthritic change in the subtalar joint that causes the pain. It also shows that in spite of fusion with the foot in the wrong position, when the correct position was obtained the symptoms were relieved. This is not a new experience. Surgeons who have been fusing the subtalar joint with the idea of getting relief for this very difficult fracture have, in reporting their statistics, shown that as high as 35 per cent had unsatisfactory results. My stand on the fusion operation is that if you cannot get relief in any other way you may consider a fusion. I have found that by taking correction of the deformity at the subtalar joint you will get relief, but if you are not able to retain the corrected position in any other way it would be permissible to retain it by means of a fusion. Here again I emphasize the value of retention by re-establishing the normal function which in this case is the re-establishment of normal gait. If you get these patients to walk correctly after you have obtained correct position, they will not have a return of the symptoms.

#### LESIONS OF THE SUBTALAR ARTICULATION DUE TO FRACTURE OF THE TALUS

Fracture of the talus offers serious problems, particularly if there is a shattered fracture with displacement of fragments. It may be necessary to operate to straighten out the fragments and remove those parts that are going to interfere, but in most cases it is a question of lining up the fracture in such a way that a good weight-bearing joint results. Where this can be obtained, a good clinical result will follow. It is obvious that a fracture of the talus will involve the joint, since most of the talus has articular surfaces. Since this is a definite weight-bearing joint, the fracture is always important. The alignment of the fracture per se is not always the criterion as to the result. In many instances the fragments may have good position and good union but with a poor result. Here again it is a question of the relationship of the bones to each other. With an altered relationship of the bones there is an altered position of the articular surfaces, and this change in the articular surfaces is going to set up friction rub, irritation, inflammation, and so on to arthritic changes. The symptoms of pain that result from fractures into articulations are seen primarily in weight-bearing articulations. In non-weight bearing joints a fracture into the joint is not nearly so significant.

In the case of the talus, therefore, we are dealing with a fracture of a weight bearing joint and a fracture into the joint. Where it involves the subtalar joint the relationship of the calcaneus is under control but in the case of the talus, once the union has occurred it cannot be altered unless the deformity is so great that surgical intervention is necessary. Since the control of the relationship is in the valgus it is important to know what type of deformity occurs in the fracture of the talus. Here again as is usually the case with increased weight bearing the calcaneus is abducted and we get a valgus deformity. Also

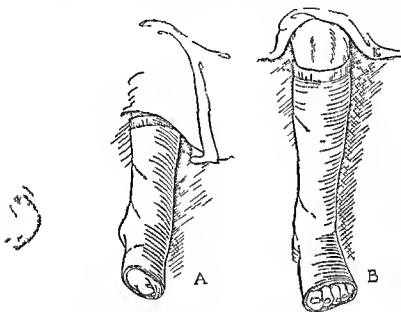


Fig 99—A Sketch of cast with the heel in varus and the anterior part of the foot in supination which will ultimately lead to pes valgoplanus. B correct position of the foot in cast. (From Hauser Diseases of the Foot.)

we have the same old difficulty in the anterior part of the foot. In putting up the fracture for retention of position the cast is frequently put up with the heel in varus and the anterior part of the foot in supination (Fig 99). It is this fixed supination that gives rise to further trouble in the end. I want to show you the x rays of such a case.

### Case Report

This man learned to fly in the last war. He continued to fly after the war and in an airplane crash he came down in such a way that he fractured the calcaneus of one foot and the os talus of the other foot. It can be seen that the fracture was in about the middle third of the talus and went through the subtalar joint (Fig 100). It did not involve the articular surface of the ankle. The

fragment healed in relatively good position, as seen by x-ray. This man came to me about six months after his injury with pain in both feet, which had persisted and for which his doctor had very little to suggest in the way of relief. He was unable to stand without severe pain.



Fig. 100.—Healed fracture of the neck of the talus (From Hauser, "Diseases of the Foot.")

**Treatment.**—The patient was hospitalized and some heat and massage were used to loosen up the articulations of the feet. Both feet were then manipulated. The heel was brought into varus and the anterior part of the foot was manipulated so that the head of the first metatarsal bone was lower than the other metatarsal bones. To the left foot, which was the one that had the fracture of the talus, a cast was applied to retain the correct position. He walked in the cast for a period of three weeks and then the corrective shoes were used. The inner side of the heel was raised  $\frac{1}{4}$  inch to form an inclined plane to obtain supination, and the comma-shaped transverse bar was raised on the outer side  $\frac{3}{16}$  inch. He was taught to walk with the heel-and-toe gait, and he gradually got rid of his limp. When the war broke out in 1941 he re-enlisted and is now in service as an officer in the Army.

**Conclusions.**—This case shows that faulty relationship of weight bearing was the cause of the man's disability and symptoms, because correction of the position of the subtalar joint gave him complete relief. The fact that the fracture had gone into the articular surface was really of no significance as long as the normal position of the foot could be retained. If the old position had been retained there is no question but that he would have developed arthritis in the region of the fracture site as well as throughout the articulation, and un-



doubtedly the talonavicular and calcaneocuboid articulations would ultimately have become involved due to their altered position when the position of the subtalar joint was changed

#### LESIONS OF THE SUBTALAR JOINT DUE TO DISLOCATION AT THE TALOCALCANEAL JOINT

Dislocations of the talocalcaneal articulation are comparatively rare. When they do occur there is also a dislocation at the talonavicular joint. They usually occur as a result of a fall with the foot plantar flexed. The deformity is apparent and the x ray shows the unusual displacement. Any attempt to invert or evert the foot is painful.

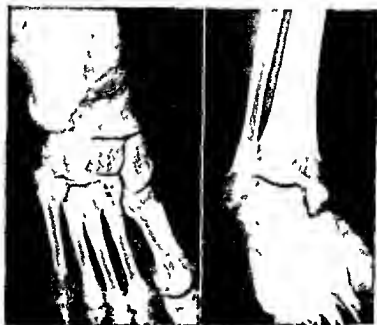


Fig 101.—Subtal.

views

Two

The treatment consists in immediate reduction under general anesthesia. The knee is held in flexion and traction is put on the calcaneus with one hand and on the anterior part of the foot with the other hand. The foot is pulled into plantar flexion and extension. While the traction is being applied the assistant holds the leg and the anterior part of the foot is forced laterally and the calcaneus is forced beneath the talus. If seen early this can be accomplished without much difficulty. Fixation is then carried out by means of plaster of paris cast. Weight bearing is started as soon as the pain has subsided and the cast is worn for from four to six weeks. Heat and massage are used, or the

second cast can be applied with a walking caliper, and this is worn for another four weeks. Then an Unna paste boot is used to prevent swelling or a Tetra bandage can be applied.

### Case Report

This man suffered an injury while loading a truck. The foot was caught and he had a sudden wrench. As you can see, the calcaneus is subluxated beneath the talus at the subtalar joint, and the head of the talus is dislocated at its navicular articulation (Fig. 101).

**Treatment**—Under general anesthesia (ethylene) traction was put to the heel and to the anterior part of the foot by the assistants. Then with the thumb and fingers the foot was easily slipped back into place. The reduction occurred without any trauma. The foot was put in cast in the mid position and walking was started, with a walking caliper, after two weeks. The cast was removed at the end of eight weeks and he went on to complete recovery.

### LESIONS OF THE SUBTALAR JOINT DUE TO TUBERCULOSIS

Usually tuberculosis of the subtalar joint is associated with tuberculosis of the ankle joint, that is, of the talocrural joint. Diagnosis is made by prolonged history, tuberculosis elsewhere, the aspiration of fluid, injection of the guinea pig and identification of the tubercle bacillus. The symptoms of pain and swelling, as well as limp and tenderness over a long period of time, should suggest the possibility. There is an atrophy of the muscles of the leg and definite atrophy of the bone, as seen by x ray, with a loss of joint space and erosion of the articular surface (Fig. 102). The ankle becomes enlarged and cold abscesses may form with draining sinuses. The virulence of the bacteria and the resistance of the individual are variables which determine the course of the disease. Healing may take place with conservative treatment in the benign cases and this is particularly true in the cases of children. When the tuberculosis becomes quiescent without bony fusion, recurrences may occur in these weight bearing joints. Conservative treatment is the treatment of choice in children and consists in aspiration if necessary to relieve the tension, and then prolonged fixation by means of cast first without weight bearing and then with weight bearing.

**Treatment**—The operative treatment consists in a fusion. The operation is carried out under general anesthesia under tourniquet. A vertical incision is made posterior to the fibula starting about two inches above the lateral malleolus and curving around to the dorsum of the foot. Both peroneal tendons, the lateral ligament and the joint capsule are divided so that the foot can be brought into extreme varus and the talocrural joint can be exposed. The tuberculous tissue in this area is removed and the bony surfaces are denuded. The talocalcaneal articu-

lation is then exposed. The articular cartilage is then removed from the dorsum of the calcaneus and the lower surface of the talus is also denuded. Occasionally the talus is so much involved and so badly destroyed that the entire talus is removed and a fusion is brought about between the tibia and fibula and the calcaneus. The foot is put in 5 degrees plantar flexion and a plaster of paris cast is applied. The cast can be changed after about four weeks and weight bearing can be started at about the sixth week.

If the entire talus is removed then the foot should be displaced posteriorly so that there is better weight bearing coming through from the tibia and fibula down into the middle of the foot. Where there is



Fig 102 Tuberculosis of the ankle joint with subtalar involvement.

delay in the fusion fixation may be obtained by means of a form fitting leather and steel brace rather than carrying out full fixation with the plaster of paris cast. Sometimes the destruction is so great and the process has so little tendency to heal particularly in the presence of a sinus with secondary infection that an amputation is the most conservative treatment.

#### LESIONS OF THE SUBTALAR JOINT DUE TO CHRONIC INFECTIOUS ARTHRITIS

Chronic infectious arthritis will involve the subtalar joint but I have never seen it involve this joint alone. When dealing with this one is simply dealing with the problem of chronic infectious arthritis and all

treatment must be directed toward the disease per se. The only additional treatment would be to give as much relief as possible to this weight bearing joint. This will be accomplished, first, by stopping the



Fig 107—Coxa vara associated with fusion of the subtalar joint. Etiology not established.

weight bearing, which means rest in bed, second, by protection which is best done by a form fitting plaster-of-paris cast well padded, and third, by retention of the best position and controlled weight bearing which means short periods of walking interrupted by periods of rest,

UNUSUAL LESION OF THE SUBTALAR JOINT RESULTING IN A SPONTANEOUS  
FUSION AND ASSOCIATED WITH COXA VARA

## Case Report

A woman 57 years of age came to me complaining of pain in the right hip and in the left foot. At the age of 10 she had had trouble with her left ankle and some trouble in the right hip. The left ankle was very painful at the time and she was disabled for two years. After that she was able to walk for a time. No definite diagnosis was established. She went along fairly well until five years ago, when she began to have pain in the hip and more pain in the left ankle.

At the time I examined her she had a flexion adduction deformity of the right hip, a pes valgoplanus on the right with a muscle spasm in the peroneal group, and it was impossible to bring the heel into varus. In the x ray one can see an unusual type of coxa vara in the right hip (Fig 103, upper), while the left foot reveals a fusion of the subtalar joint (Fig 103, lower). One can also see the secondary arthritic changes at the talonavicular and some at the calcaneocuboid articulations.

**Diagnosis.**—This is an unusual case of spontaneous fusion of the subtalar articulation of the left foot, associated with coxa vara of the right hip.

**Treatment.**—When first seen a week ago the heel was brought into varus by simple strapping with adhesive tape, movement occurring at the ankle joint. Today the patient says she has the first relief since she can remember, and wishes to be taped again. We will repeat the strapping, but intend to take further correction by means of the corrective shoes.

## FRACTURES INVOLVING THE ARTICULAR SURFACES OF THE OS CALCIS\*

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In reviewing some of the literature on os calcis fractures we find that most of the cases reported come under four main types: (1) the so called 'open beak' fractures, (2) fracture of sustentaculum tali without other injury to the os calcis, (3) a break in the continuity of the plantar weight-bearing portion of the heel without involving the articular surface, (4) the severe crushing injury causing comminution of the bone and involvement of the articular surface.

There is considerable variance in the reports relative to the amount of permanent impairment in os calcis fractures. I believe that this is due to the fact that some of the reporting authors do not properly classify the fractures. In general the reports agree that the fractures in which there is considerable comminution of the bone with involvement of the articular surface show long periods of disability and a rather high percent of permanent impairment. Inasmuch as the other types of fracture are less frequent and less troublesome this presentation will deal mainly with seventeen cases of the comminuted type of fracture which involves the articular surface.

### ETIOLOGY

The cause of the fractures in this series of cases, and most of those reported in the literature, is a fall from a height of 8 or more feet, with the patient landing on his heels. It appears, therefore, that there are two main forces involved in the production of the displacement in this fracture. Bohler,<sup>1</sup> in his article in which he introduced his method of reduction into this country, shows that the displacement longitudinally of the fragments is due to the pull of the Achilles tendon (Fig 104, D) on the proximal fragment and the pull of the anterior leg muscles on the distal fragments (Fig 104, E).

In addition to this we have the downward force of the body (Fig 104, A) carried by direct contact of the astragalus to the superior surface of the os calcis. The os calcis is also fixed against the ground at its posterior extremity (Fig 104, B). At its anterior extremity as it strikes the ground there is also another resisting force transmitted to

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it from the proximal end of the fifth metatarsal through the cuboid (Fig 104, C) This combination of forces would cause the fracture to

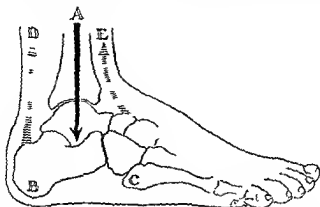


Fig 104—Diagram showing forces involved in fracture of the os calcis (For explanation see text)

occur near the middle of the heel, and would cause plantar angulation of the fragments (Fig 105) The same force carried down through

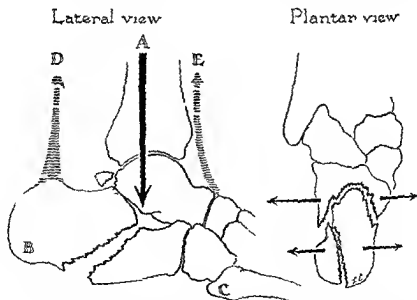


Fig 105—Lateral and plantar views of fracture of the os calcis

the middle of the superior articular surface of the heel would also cause lateral displacement of the fragments from a sagittal line of fracture (Fig 105)

## TREATMENT

The method which we have used in treating these cases is similar to that reported by Herman.<sup>6</sup>

One variation in the principle and technic of getting the posterior and distal fragments into apposition should be emphasized. Methods which necessitate the application of skeletal traction through either the posterior extremity of the os calcis or just above the point of insertion of the Achilles tendon are concerned primarily in an attempt to bring the proximal fragments, by traction, into apposition with the distal fragment. We have also observed that in the use of methods



Fig 106—Correcting anteroposterior displacement of fragments by hand manipulation

dependent entirely on manipulation extreme plantar flexion of the ankle is not always emphasized. Therefore, in our procedure the manipulative force is exerted in an attempt to bring the distal fragment into contact with the proximal fragment, by *extreme plantar flexion of the foot*.

With the patient lying on his back with the knee flexed at right angles, the leg hanging over the end of the operating table or cart, most of the pull of the gastrocnemius muscle is removed. While still in this position the ankle is plantar flexed to its maximum limit, which still further removes traction on both the gastrocnemius and soleus muscles and on the plantar muscles. In this position any impaction is



broken by manipulating the heel and ankle. Then, by manipulating the fragments with the hands and increasing the elevation of the longitudinal arch, the anteroposterior displacement of the fragments can usually be corrected (Fig. 106).

**Reduction**—The next step in the procedure is the *reduction of the lateral displacement of the fragments*. Without changing the position of the leg, lateral compression is brought to bear upon the fractured heel. Frequently this can be done by interlocking the fingers of the surgeon beneath the plantar surface of the heel and applying the compression by bringing the heels of the operator's two hands together (Fig. 107). Where there is considerable comminution and



Fig. 107—Reduction of lateral displacement of fragments by hand manipulation

widening this procedure may not be sufficient. If such is the case a Forrester bone clamp or an ordinary carpenter's C clamp may be used to restore the normal lateral contour of the heel.

Much of the soft tissue swelling can be massaged away and the operator can usually tell fairly well by palpation and inspection whether or not there has been adequate reduction of the width of the fractured heel. So far we have not found it possible to get a good anteroposterior fluoroscopic view of the heel with the patient in this position. However, by carefully noting the width of the heel, particularly the relation of its collateral surfaces with the malleoli, fairly accurate information may be obtained. The lateral view can be checked quite satisfactorily by means of the fluoroscope before the

application of the cast. In this view particular attention should be paid to the restoration of Bohler's "tuber-joint angle." To summarize then if the lateral fluoroscopic view shows satisfactory restoration of the tuber joint angle together with normal anatomical restoration of the other peripheral surfaces of the heel, and inspection shows normal restoration of the relationship of the collateral surfaces of the heels with the malleoli, we may assume that satisfactory reduction has been obtained. All this should, of course, be checked with anteroposterior and lateral x rays of the os calcis, usually done on the following day when the cast is dry.



Fig 108—Lateral compression on heel during hardening of plaster

**Application of Cast**—With an assistant still holding the ankle in full plantar flexion a cast is applied, extending from the bases of the phalanges to a point just below the knee. No padding is used, except one layer of stockinette and a long, very thin strip of felt to protect the anterior crest of the tibia and a thin strip of felt to protect the skin from the distal and proximal edges of the cast. Inasmuch as the actual application of the cast takes very little time, fast setting plaster is used and while it is in the process of hardening *considerable lateral compression* is brought to bear upon the heel, moulding the cast in firmly with the heels of the two hands (Fig 108). This is the most fatiguing part of the procedure, but it is very important to maintain this collateral compression until the plaster becomes firm.

Another phase in which this method varies from many reported is the *absence of any waiting period* between the time of the fracture and its reduction and the application of the cast. In other words, the reduction and the application of the cast are made just as soon as the patient and the doctor can get to the hospital, can have proper x rays taken and an anesthetist be obtained. We consider this an emergency fracture, and in practically all cases this interval has been only a matter of one to three hours. There has been no difficulty with additional swelling after the application of the cast. In fact, with the legs kept comfortably elevated, we have found that within two to five days the



Fig. 109—Method of tightening cast after two to five days

cast becomes quite loose, and has to be tightened by the method described below (Fig. 109)

The *anesthetic* usually used is some gas induction, reinforced by ether at the time of the reduction, as at this stage surgical anesthesia is required. There are, of course, several other anesthetics which could be used, depending upon the condition of the patient. The time of the whole procedure from the time the anesthetic is started to the time at which the cast becomes firm is usually from thirty to forty-five minutes.

**Later Care.**—From this point on the after-care follows very closely that outlined by Herman. At the end of about two to five days after

the application of the cast a strip about  $\frac{1}{8}$  to  $\frac{1}{4}$  inch wide is removed with the cast cutters or a knife from the posterior and plantar aspect of the cast (Fig 109, *a*). This defect is then closed by bringing together the edges of the cast thus formed and holding them temporarily with wide adhesive strips (Fig 109, *b*). This position is then maintained permanently by applying one more plaster bandage.

At the end of about ten more days this cast is then removed and a new one just like it applied. During this change of casts great care is taken to avoid changing the position of the ankle and heel or manipulating it in any way. As this cast hardens a maximum amount of manual lateral compression is again brought to bear upon the heel by the heels of the two hands (Fig 108). In about two weeks this cast is again changed. Each procedure is performed every four weeks until all immobilization is removed in about twelve to fourteen weeks after the fracture. This means that every two weeks steps are taken to keep constant lateral pressure on the collateral surfaces of the heel.

In brief then the approximate chronological sequence is as follows:

Immediate reduction and cast

At the end of 2 to 3 days cast tightened

At the end of 14 days new cast

At the end of 4 weeks cast tightened

At the end of 6 weeks new cast

At the end of 8 weeks cast tightened

At the end of 10 weeks new cast

At the end of 12 weeks cast tightened

At the end of 14 weeks cast removed

The next step is *active motion*, followed in a week by gentle passive motion. The patient is encouraged to exercise and manipulate his feet himself, within the limits of comfort. Hot, wet applications and exercises in hot water have been found to be very beneficial in restoring function. About sixteen weeks after the fracture the patient is encouraged to begin weight bearing, at first using crutches, and from this point on gradually increasing the amount of weight bearing as rapidly as is compatible with his comfort.

**Results of Method**—The following figures illustrate the effectiveness of this method in obtaining reduction. Figure 110, *a*, shows a lateral view of the heel taken after the injury. Figure 110, *b*, shows the position of the fragments after manipulation and application of the cast. Here there appears to be some increase in the amount of displacement with persistent distortion of the tuber-joint angle. At this time the above method was suggested to the doctor. He proceeded without any assistance from the authors and Figure 110, *c*, shows satisfactory reduction. Figure 110, *d*, is the most recent lateral view. This case is too recent to be included in the analysis of the cases reported below, although the man is now working and is making only minor subjective

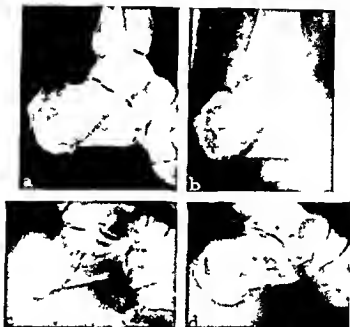


Fig 110 *a* Lateral view of heel after injury *b* Poor reduction with ankle at right angles *c* Satisfactory reduction with ankle in plantar flexion *d* Most cent lateral view

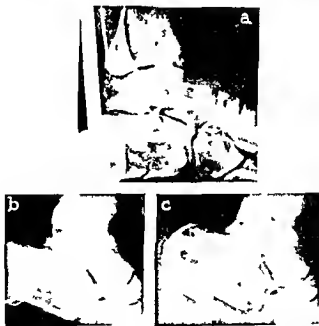


Fig 111—*a* Lateral view of heel to which traction had been applied for one week *b*, Result after manipulation and application of cast *c*, After removal of last cast fourteen weeks from time of injury

complaints. Clinically the heel is of normal contour and the ankle has good motion.

Figure 111, *a*, shows a lateral view of a heel to which traction has been applied by means of a Steinmann pin through the posterior fragment. This traction had been in place one week before our examination. Comparison with x rays taken previously showed that there had been no improvement in the alignment of the fragments. Figure 111, *b*, shows the result after manipulation and application of the cast, according to the method described above. Figure 111, *c*, shows the view taken after the removal of the last cast, approximately fourteen weeks from the time of injury. This case is also of much too recent origin to be included in the analysis below. However, the patient's condition is about the same as that of the patient just previously described.

There has been no unusual difficulty in getting full return of dorsal flexion to the ankle. Usually with the physical therapy steps described above the ankle can be dorsiflexed to almost normal degree within two to four weeks after the removal of the last cast. When final impairment rating was made it has usually been made mostly on the presence of subjective symptoms. By the time the rating is made there is usually full motion of the ankle with the exception, occasionally, of slight limitation of inversion and eversion of the ankle joint, and sometimes a little increase in the width of the os calcis.

#### DISCUSSION OF CASES

Before summarizing the cases in which the articular surface was involved we would like to discuss briefly a few cases that are not analyzed in this series.

Six cases were treated in which the articular surface was not involved. Five of these recovered without permanent impairment, one was awarded a permanent partial impairment of 5 per cent below the knee although there was no objective evidence indicating that the amount of impairment actually existed. This is mentioned to emphasize again the point that in reporting final results in os calcis fractures particular attention should be paid to see that an accurate classification of the fractures reported is made.

Cases of fractured heels complicated with other fractures such as fractures of the metatarsals and spinal fractures will not be considered in this analysis because they also complicate somewhat the evaluation of the results.

We also had an opportunity to examine ten other cases in our office which had their early treatment elsewhere. These cases all showed high impairment ratings, due to pain, limitation of motion and widening of the heel ranging from 20 to 30 per cent to 80 or 85 per cent of the leg below the knee. Some of the fractures were not diagnosed early, some had traction with pins and the application of a single cast,

some were treated with metal splints and large padded casts. Two of them had an arthrodesis, but still had a high degree of impairment. This is simply another sample of cases similar to the twenty two cases reported by Cotton in 1908, in which the fractures were treated rather indifferently and in which more than half had serious permanent impairment.

The seventeen cases reported below are those which were treated in the Indianapolis Industrial Clinic for injuries sustained in 1938, 1939, 1940 and 1941. These cases represent only those in which the entire treatment was carried out in this clinic. It includes only those cases in which there was comminution with three or more fragments in involvement of the articular surfaces and where displacement was sufficient to necessitate manipulation and reduction under anesthesia.

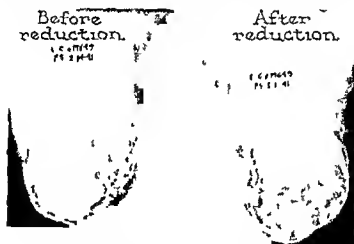


Fig. 112—Fracture of os calcis before and after reduction

These were all compensation cases and the impairment was for the most part awarded on some subjective symptoms of discomfort. Objective findings seemed to have little or no relation to the amount of impairment, inasmuch as they were noted in some of the cases which had no difficulty with their ankles or feet. Probably, therefore, the end results in similar fractures in which the question of compensation is not involved would show a smaller degree of impairment.

Figures 112 and 113 are examples of the x-ray appearance of the fractures treated. Some of the fractures showed more comminution and some better reductions than shown in these views, which are used because they also illustrate the "open beak" or avulsion type of fracture. They show a fair reduction of the widening of the fractured os calcis and a fairly good restoration of the contour of its collateral surfaces.

Figure 113, *a*, shows the avulsion at the posterior end of the os calcis and the almost complete obliteration of the tuber joint angle. If the obliteration of this tuber-joint angle was not noted the conclusion might be drawn from the x-ray appearance of the bone itself that there was much less comminution and shearing present than there actually is. This illustrates the importance of checking carefully this tuber joint angle for reduction.

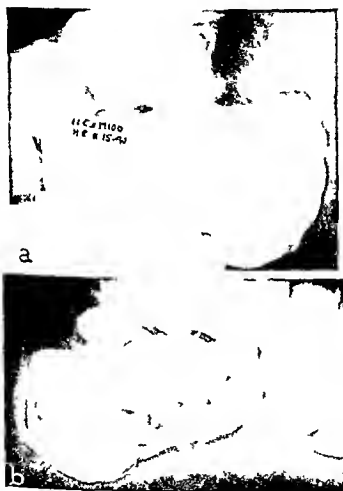


Fig 113—*a* Avulsion at posterior end of os calcis and almost complete obliteration of tuber joint angle *b*, Almost complete reduction of open beak fracture and restoration of tuber joint angle to about 30 degrees

Figure 113, *b*, shows the almost complete reduction of the "open beak" fracture and the restoration of the tuber joint angle to about 30 degrees which is not quite as good as should ordinarily be obtained this angle being usually nearer 35 degrees.

The results in the seventeen cases are analyzed in the accompanying tabulation. Grading the first two columns in the summary of this table as good or satisfactory we have 77 per cent. Classifying the third



## RESULTS IN SEVENTEEN CASES

Case	Age	Heels	Disability	Impairment
1—FD	41	2	12 weeks	None
2—WW	38	1	Able to work sitting	None
3—EM	73	1	18 weeks	None
4—VM	40	1	18 weeks	None
5—CT	42	1	18 weeks	None
6—JD	45	1	18 weeks	None
7—FS	45	2	21 weeks (20 partial)	16½ per cent
8—RS	29	1	21 weeks	31 per cent
9—GV	73	1	32 weeks	40 per cent
10—GW	40	1	18 weeks	None
11—FS	56	2	31 weeks	25 per cent each
12—LV	24	1	23 weeks	5 per cent
13—RA	59	1	24 weeks	None
14—JC	53	1	1 week (supervisor)	None
15—SWF	66	2	37 weeks	100 per cent
16—JMC	62	1	20 weeks	14 per cent
17—JA	72	1	18 weeks	None

## SUMMARY OF RESULTS

Age 24 to 73  
 Disability none to 37 weeks  
 Impairment none to 100 per cent

Average 30.4 years  
 Average 19+ weeks  
 Average 35 per cent

No Impairment	5 to 17% Impairment	25 to 40% Impairment	100% Impairment
10 cases 11 heels 59% of cases	3 cases 4 heels 18% of cases	1 cases 4 heels 18% of cases	1 case 2 heels 5% of cases

column as fair or poor we have 18 per cent, which leaves 5 per cent of our cases as very poor.

The above results show approximately the same ratio as those reported by Herman who summarizes his cases as follows: good results 73 per cent, fair results 14 per cent, poor results 13 per cent. Taking two cases from our 25 to 40 per cent impairment column and classifying them as poor, our poor results percentage would be about 18 per cent, approaching the 13 per cent of Herman.

The period of immobilization may to many men seem quite long. However, attention should be called to the fact that fractures involving red marrow bone heal much more slowly than fractures in the shafts of the long bones, where there is yellow marrow. Examples of this are the prolonged immobilization necessary for the intracapsular fractures of the neck of the femur and fractures of the carpal scaphoid. The

tarsal bones of the foot are of the same type, so this period of immobilization is probably very necessary.

Had these seventeen cases been treated by men advocating immediate arthrodesis, or an arthrodesis within six to eight weeks after preliminary manipulation, thirteen would have been subjected to an operation, which would have been entirely unnecessary. Of the three cases showing an impairment of 25 to 40 per cent and the one of 100 per cent, possibly two could have been helped by an arthrodesis. The man showing 25 per cent impairment is not having too much difficulty in his activities.

#### SUMMARY

In conclusion we wish to state that the method reported above is not intended to be the last word in handling os calcis fractures, but it, or a similar conservative method which maintains constant lateral compression, plantar flexion and upward moulding of the longitudinal arch should be used first. There will probably occasionally be cases which cannot be satisfactorily reduced and held in position in this manner. When such occurs probably Bohler's, or a similar technique, will be required.

These cases are presented to give added support to the work of Herman and his statement that, "Initial destructive operative procedures should not be adopted as the first treatment of fractures of the os calcis. This and other special operations should be reserved for selected cases, those cases in which conservative treatment alone has not been effective."

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## BEADED WIRES IN TREATMENT OF FRACTURES OF THE LEG

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No other period in the history of treatment of fractures of the leg has given us such a variety of methods as the present time. Numerous types of steel and steel alloy metal bone plates and screws have been advocated. Application of Steinmann pins and Kirschner wires has been advocated in many different techniques from simple skeletal traction and cruciate insertion to dual pin fixation. While the method may be successful in the hands of the surgeon proposing it, failures may be obtained by the majority of others who use it. It must always be kept in mind that the percentages of fractures cared for by experienced men is very small. Therefore it is our responsibility to direct attention to conservative simple yet efficient methods in treatment of fractures.

The perfect anatomical reduction is greatly to be desired; it is true, but what is most important to the patient and should be to us is a good functional result. We have all observed perfect anatomical reduction of fractures of the leg with a poor functional result, which may have been due to extensive surgery resulting in circulatory disturbances, fibrosis or osteomyelitis complicated by metal bands, screws, plates or pins.

### COMPARISON OF FIXATION METHODS

Personal experience has taught that if a fracture can be reduced and maintained in plaster it is the method to pursue since it offers the best result. However, not all fractures of the leg can be treated in this manner, especially oblique and spiral fractures of the tibia. A cast offers no control (Fig 114). Dual pin fixation above and below the fracture exhibits remote control with pins making eight large holes in the cortex, destroying several trabeculae and offering additional avenues for infection (Fig 116).

For these reasons the simplest measure is provided for us in the beaded Kirschner wire developed by Thomson and Ferciot<sup>1</sup>. It has been used in over sixty-eight cases of closed reduction of fractures of the leg with exceptionally good results. It affords positive local control of the fragments which cannot be said of any other closed method (Fig 117). Furthermore, the caliber of the fine Kirschner wire causes a minimum of trauma to the bone. There has been no incidence of osteomyelitis or nonunion in any of the cases treated.

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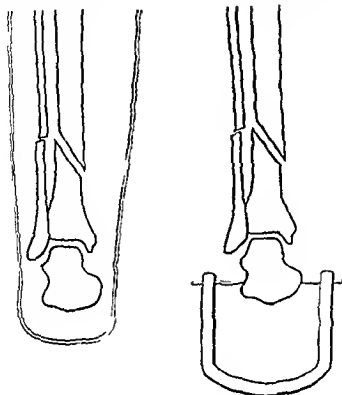


Fig 114 -Plaster cast-"no control" Fig 115 -Pin in os calcis-"no control"

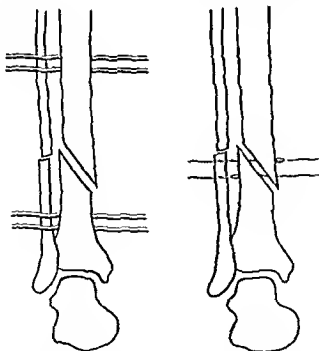


Fig 116

Fig 117

Fig 116 -Dual pin fixation-"remote control"

Fig 117 -Beaded wires-"local control" Positive fixation

## TECHNIC OF BEADED WIRE TREATMENT

A detailed description of the beaded wire technic was outlined in a previous publication and is as follows,<sup>2</sup> "Before the initial steps in reduction are undertaken, a careful study of the roentgenograms is most important. The reason for this is to determine the shape, position and number of the fragments to ascertain the direction of insertion of the beaded wires. With the patient on a fracture table and general anesthesia, a plain Kirschner wire is drilled through the os calcis. A bow is then applied and fastened to the foot piece of the fracture table after which screw traction is applied until the fragments can be gently manipulated into position.

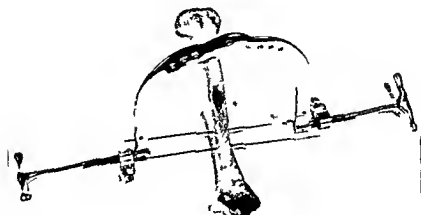


Fig. 118 Double transverse traction bow (Courtesy of Surgery, Gynecology and Obstetrics)

The site of election for drilling one beaded wire can be easily determined by palpating the end of a long fragment aided by the knowledge received from the roentgen examination. However, the area may be selected by use of the fluoroscope.

"The beaded wire is then drilled into the bone. A puncture wound must be made in the skin to admit the bead, but it is not necessary or recommended that the incision be any deeper than the skin. When the bead strikes the bone, further progress of the wire is naturally stopped thus indicating a satisfactory insertion. With this wire acting as a landmark the remaining beaded wire or wires to be drilled are introduced alternately in opposite direction. A Kirschner bow with Thomson attachment or the double transverse traction bow is then applied and fragments are brought together (Fig. 118). "A long leg cast is applied and after it has set, tightening bolts are fastened to the

protruding wires in order to hold the beads firmly against the bone. A washer or slotted metal piece may be placed between the bolt and the cast so that the latter will not become indented. After the tautening bolts are applied the wire in the os calcis used for traction is removed. A long metal "U" shaped bar in which small holes have been drilled at quarter-inch intervals is incorporated in the cast for use in compound fractures" (Fig. 119). The wires are then directed through one of the holes and the tautening bolts are attached to the wires on the outside of the bar. By this means it is not necessary to use counter

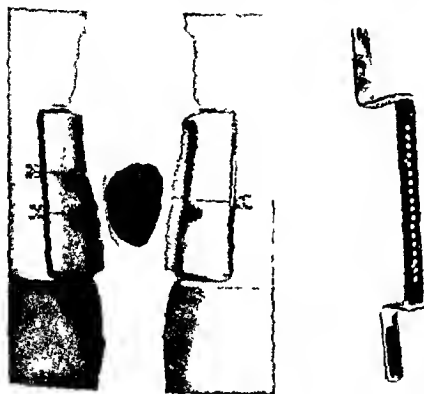


Fig. 119—Cast with perforated "U" bar against which tautening bolts are placed. Used in compound fractures so that cast may be fenestrated. (Courtesy of Surgery, Gynecology and Obstetrics)

pressure on the cast by the bolt which allows the removal of the plaster over the denuded area so that the wound may be dressed.

"After reduction roentgenograms are made for confirmation of position and, if there has not been adequate transverse traction at the time of reduction, the slack can be taken up by the screw in the tautening bolt.

"It is not necessary to apply skin tight or snug fitting casts, but on the contrary a generous amount of padding is recommended which allows for possible swelling of the extremity. The quantity of sheet wadding used does not interfere with the immobilization of the leg

Although the function of the cast is to support the *extremity* this is not of primary importance. The salient point is that it serves as a reinforcement against which the *tautening bolts* maintain continuous opposing traction of the wires. The *fixation* thus being against the



Fig 10 a Oblique and spiral fractures of the tibia and fibula b Reduction of the oblique fracture beaded wire fixation c End result

bone the cast is not necessary for maintenance of position of the fragments

After recovery from the anesthetic the patient may be ambulatory and leave the hospital. Weight bearing with crutches is permitted

After five or six weeks the cast and wires are removed, and a snug fitting cast is applied allowing full weight bearing as soon as the cast is dry. A block of rubber or ball of plaster is incorporated in the bottom of the cast to facilitate walking. The plaster ball is recommended because it is harder than the rubber and gives a firmer impact with each step thus giving more stimulus to new bone formation.

#### FRACTURES OF THE LEG

Figure 120 demonstrates an oblique fracture at the junction of the upper and middle thirds of the tibia with a spiral fracture in the lower



Fig 121—*a* Comminuted oblique fracture of the tibia and fibula *b* Fixation by beaded wires *c*, End result

third without appreciable displacement. This occurred in a male 44 years of age. Reduction was accomplished as described above, beaded wire inserted in the upper fracture, cast applied, tightening bolts attached to the wires. The Kirschner wire in the os calcis used for trac-



tion removed and the patient sent to his room. The patient was discharged from the hospital walking on crutches three days later.

Another oblique fracture of the tibia is demonstrated (Fig. 121). This occurred in a male aged 23 who after reduction left the hospital the next day.

The compound fracture of the lower end of the tibia and fibula shown in Figure 122 occurred in a male aged 19. A cannula was placed



Fig. 122—*a*, Compound, comminuted short spiral fracture of the tibia and fibula, also the os calcis. *b*, Reduction by beaded wires. *c*, End result. Note reduction of fracture of os calcis.

in the wound which was irrigated with Ringer's solution, the debridement being carefully performed as the solution flowed. Irrigation was continued while a straight Kirschner wire was passed through the os calcis and traction applied on a fracture table. After irrigation was discontinued sulfanilamide powder was dusted into the wound, which was then closed with interrupted sutures. Beaded wires were inserted as if the fracture were a simple one. After approximation of the frag-

ment with the double transverse traction bow a cast was applied, the tightening bolt fixed to the wires and the bow removed. The cast was fenestrated at the site of the wound. Fortunately, healing took place

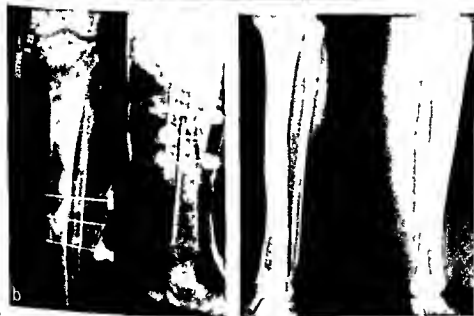


Fig 123—*a*, Bumper fracture *b*, Reduction by three beaded wires *c*, End result

by primary intention and the patient left the hospital in two weeks. Please note that this patient also sustained a fracture of the os calcis which was reduced as a result of the skeletal traction applied through the os calcis, utilized primarily for reduction of the leg fracture

In bumper fractures with a large triangular piece of bone separated from the shaft three beaded wires are used—two from one side being passed through the upper and lower fragments, respectively, and one



Fig. 124—*a*, Transverse fracture with traction through the os calcis after three weeks *b*, Reduction with beaded wire fixation *c*, End result

" *c* —rest against the two  
aged 50

Many times sufficient skeletal traction is applied to inverse fractures of the tibia, but *lateral displacement* is not overcome. Figure 124,

*a*, shows such a case in a boy aged 17, first seen after three weeks with traction through a Steinmann pin in the os calcis, lateral displacement persisting. By insertion of beaded wires alignment was obtained with some angulation at the fracture site (Fig 124, *b*). After three weeks the wires were removed and the angulation corrected and position maintained in a long leg cast. The end result was most satisfactory (Fig 124, *c*).



Fig 125—*a* Severely comminuted fracture of lower end of femur with skeletal traction. Fragments uncontrollable. *b* Fixation with beaded wire. *c*, End result.

Similarly, skeletal traction applied to the femur in a man aged 58 was not enough to correct the displacement illustrated in Figure 125, *a*. With the skeletal traction being continued beaded wires were inserted and traction on the wires was maintained with the double transverse traction bow until there was sufficient callus formation (Fig 125, *b*). The end result is shown in Figure 125, *c*. There was only a 10 degree loss of motion to complete flexion of the leg.

Figure 126, *a*, shows bilateral almost identical comminuted fractures of the lower lateral articulating portion of the tibia with outward displacement of the lateral fragments. These occurred in a man aged 46. It was thought an open reduction was imperative but an attempt at closed reduction proved successful. Beaded wires were then inserted



Fig. 126—*a* Comminuted fractures of lateral tibial articulations *b* Reduction with beaded wires *c* Result at end of five months

to fix the fragments (Fig. 126 *b*). The end result five months later is shown in Figure 126, *c*.

#### TIBIOFIBULAR DISLOCATIONS

The use of the beaded wire greatly simplifies the treatment of the distal tibiofibular dislocations. Figure 127, *a*, is a film of a man aged 35, who had such a dislocation. A walking cast had been applied apparently without any attempt at reduction. He was first seen by me ten days later at which time the cast was removed and a beaded wire drilled through the fibula and tibia as shown in Figure 127 *b*. End result is demonstrated in Figure 127, *c*.

Figure 128 illustrates the method of reduction of tibiofibular dislocation with a felt pad placed on the medial aspect of the lower end



Fig 127—*a*, Unreduced tibia (fibular dislocation of ten days' duration). *b*, Closed reduction with beaded wire. *c*, End result

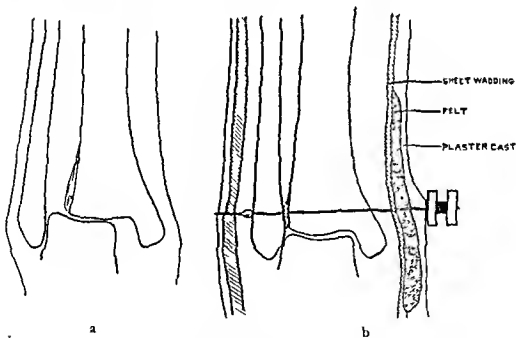


Fig 128—*a*, Diagram of tibiofibular dislocation. *b*, Closed reduction fixation with beaded wire.

of the tibia and ankle joint region, which distributes the counter pressure when tension on the wire is accomplished by expanding the tautening bolt.

## FRACTURES OF PATELLA

On rare occasions fracture of the patella may be reduced and fixed by the closed beaded wire method. These are cases when there are



Fig 129—*a* Fracture of patella *b* Reduction with beaded wire *c* Lateral view of both patellae showing end result

only two almost equal-sized fragments without much displacement with the capsular insertions of the vastus muscles intact. One case occurring in a male 29 years of age, has been treated by inserting into the patellar fragments one beaded wire from above and another from below. The transverse traction bow was then applied to the wires and the fragments brought together. A circular plaster cast was applied long enough to accommodate the trauening bolts. The patient was ambulatory the next day. In three weeks the wires were removed and active motion instituted. The end result was exceptionally good with scarcely 5 degrees of loss to complete flexion of the leg (Fig. 129).

#### USE OF BEADED WIRES IN OPEN REDUCTION

Beaded wires are useful in a selected group of fractures of the leg where screws and bolts have heretofore been used. Such cases are mainly fractures of the tibial plateau and posterior malleolus.

**Tibial Plateau Fractures**—The first step in replacing the tibial condyle is application of skeletal traction by means of a Kirschner wire inserted through the lower end of the shaft of the tibia or through the os calcis.

An incision is then made on the anteromedial or anterolateral aspect of the proximal end of the tibia depending upon the respective side involved. After replacement of the fragment the beaded wire is drilled through the skin about one inch posterior to the incision. The wound is then closed and a long leg plaster cast is applied including the foot. A trauening bolt is applied on the opposite side to maintain the firm fixation. The leg traction wire is then removed. The patient may be ambulatory the next day. In five or six weeks the cast is removed along with the beaded wire after which active and passive motion is instituted.

Treatment by the beaded wires appears superior to many other methods proposed inasmuch as no metal is left in the bone permanently, and two incisions are not necessary as in the case of the stove bolt and nut. Bolts and screws may loosen, and if separation of the fragments occurs there is no way of replacement, but if this occurs with the use of the beaded wire all that is necessary is to tighten on the trauening bolt.

A lateral tibial plateau fracture replaced as described above is demonstrated in Figure 130. This fracture occurred in a man aged 55. The knee joint was exposed through the anterolateral aspect and the displaced and lacerated internal semilunar cartilage was removed. Fragments of bone found in the knee joint were removed. The wound was then closed, a long leg cast applied and a trauening bolt attached to the wires to insure maintenance of position. A satisfactory stable knee joint was obtained.



Figure 131, *a*, demonstrates an exceptionally comminuted fracture of both condyles occurring in a man 55 years of age. Upon opening the knee joint so much involvement of the articular surface of the tibia presented itself that an immediate fusion of the knee joint was



Fig 130 *a* Lateral tibial plateau fracture *b*, Open reduction fixation with beaded wire *c*, End result



Fig 131—*a* Commminuted fracture of both condyles *b*, Open reduction with beaded wire fixation *c*, End result

believed to be justified and was considered. However, an attempt to replace the fragments was decided upon, and fortunately reduction was accomplished after removal of the destroyed external meniscus. Beaded wires were used to maintain position of the larger fragments (Fig 131, *b*). Three months later repair of the medial collateral liga-

ment was performed by use of fascia lata. The end result was very satisfactory with good stability of the knee and only 25 degrees loss of motion to complete flexion (Fig 131, *c*).

**Posterior Malleolar Fractures**—The use of the beaded wire in posterior tibial malleolar fractures is shown in Figure 132. This occurred in a woman of 49 who when first seen had had three manipulations under general anesthesia within a four week period. There was no alternative but open reduction.

With the patient prone a 4-inch incision was made on the posterolateral aspect of the lower end of the leg extending into the tibioastragalar joint. The displaced posterior fragment of the tibia was



Fig 132.—*a* Posterior malleolus fracture with dislocation of the astragalus of four weeks duration *b*, Postoperative reduction fixation with beaded wires

dissected from a mass of dense fibrous tissue, the opposing surfaces freshened and reduction accomplished. A beaded wire was inserted through the skin just lateral to the incision and drilled through the shaft of the tibia so that it emerged at the anteromedial aspect of the leg. The incision was sutured, a short leg cast applied and a tautening bolt applied to the emerging wire on the anterior surface of the lower end of the leg. After four weeks the cast and wire were removed. A new cast was applied and weight bearing allowed after eight weeks.

#### FRACTURE DISLOCATIONS OF THE KNEE

The beaded wire was used with surprising success in a difficult situation presented by a fracture dislocation of the knee joint associated with complete tears of the medial collateral and anterior cruciate ligaments. This occurred in an underweight, undernourished man 72 years of age (Fig 133, *a*).

Through lateral incision in the lower half of the thigh the fascia lata which was unusually narrow and atrophic was detached near its



Fig 113—*a*, Fracture-dislocation of the knee joint with destruction of both cruciate and medial collateral ligaments *b*, Unsuccessful repair of ligaments. *c* Fixation with beaded wires

proximal end and dissected distally in the region of the lateral femoral condyle. It was then twisted into a rope and passed through the intercondylar notch into the knee joint. Through an incision on the medial side of the knee and extending downward to the upper fourth of the tibia a  $\frac{3}{4}$  inch hole was drilled diagonally into the medial aspect of the tibia two inches from the articular surface and extended through the tibial spine. The fascial lig, which was passed through the femoral intercondylar notch, was inserted through the tunnel extending from the knee joint to the medial aspect of the tibia where it was sewed to the periosteum with silk. The remaining portion of the fascial lig was carried upward and secured with silk to the medial femoral condyle thus forming a medial collateral ligament. The fascial lig was so atrophic that it was doubted that it would hold. This doubt was substantiated as demonstrated in Figure 133 *b*. The cast which had been applied was removed two days later and a beaded wire was inserted into the femoral and tibial condyles, and satisfactory maintenance of position was obtained. After six weeks the cast and wire were removed and active and passive motion instituted. A mediocre result was expected but surprisingly, the knee joint was exceptionally stable. A hundred and ten degrees of flexion was obtained at the knee joint.

#### SUMMARY

The several cases presented demonstrate a procedure that should be included in the armamentarium of all those who treat fractures. Certainly it has its limitations, but just as positively it has a definite place in the management of certain fractures outlined above. No expensive equipment is necessary. Reductions are accomplished without trained assistants. This procedure diminishes the number of open reductions of the leg, thereby avoiding the disadvantages of incision notably, vascular interference and possible infection. No foreign material is left in the bone. The patient may be ambulatory as soon as recovery from the anesthetic is accomplished.

In the sixty eight consecutive cases of reduction of fractures of the leg using the beaded wires there has been no instance of union or infection.

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# REFRIGERATION IN TRAUMA OF THE EXTREMITIES

R T McELVENNY, M D \*

ALTHOUGH the beneficial effects of heat and cold on tissue have been appreciated for years, the paucity of knowledge relative to the pathologic changes produced in tissue by these agents has been outstanding

Through the centuries man must have been aware of the numbing effect of cold as exhibited in frostbite and in exposure. But judging by the recent display of interest, cold as a therapeutic agent may seem to many a new adjunct in medicine. This is hardly true. According to Doane, Severino, an Italian, wrote a monograph in 1646 on the use of freezing mixtures of snow and ice for the production of surgical anesthesia.

In our time some of the most stimulating work on cold as a therapeutic agent was done by Fay and Smith of Philadelphia and they endeavored to halt the growth of generation of the body. Later these workers and their colleagues adapted the principle of local application of cold to the control of local pain.

## ALLEN'S PRINCIPLES

Allen, during the same period, through exhaustive experiments on animals, set forth the principles that have guided all work and development that this paper has to do with—namely, the cooling of extremities afflicted by trauma or sepsis.

Allen's principles include the following:

1 Heat applied to tissue already deprived of normal blood supply has but one mass effect. This is to increase local tissue metabolism. This increase in turn demands a greater oxygen supply. This increased demand for oxygen hastens the disintegration of tissue because this demand cannot be met.

2 Heat by attempting to increase blood supply favors absorption of toxins from the affected part.

3 Heat by maintaining warmth in already depleted and disintegrating tissue, greatly encourages the growth of bacteria and the advance of infection and gangrene.

4 Cold, on the other hand, decreases tissue metabolism, cuts down the oxygen demand of tissue, diminishes absorption and formation of toxins, and discourages bacterial growth.

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5. Cold, in addition to the above, has the property of producing anesthesia when applied to the skin surfaces.

**Application of Principles.**—These principles as set forth by Allen have received extensive clinical trial during the past four years and have been found tenable. The practical effect has been that cold is now used therapeutically as an anesthetic, to combat absorption of toxins, to hold bacterial growth in abeyance and to prevent and combat shock.

Crossman, Hurley and other workers have during the past few years reported a large series of persons whose limbs have been subjected to cooling and subsequently amputated with no other anesthetic except that provided by conling.

### EFFECT OF COLD ON TISSUES

The effect on tissue of severe cold or prolonged cooling has, because of the war, received more intensive investigation than ever before. As is generally known, two conditions, that of immersion foot in our armed forces and that of severe frostbite in our air forces, have been major causes of disability.

According to Muirhead, thermal injury due to freezing causes the loss of large amounts of protein-containing fluid at the site of thawing tissue. This fluid is derived from the circulating blood plasma, and its loss is accompanied by the development of shock. A similar type of shock results from cooling of peritoneal surfaces.

In these respects thermal injuries due to freezing and burns resemble each other closely.

For example, a severe freeze of one entire hind limb of a dog is a reliable and simple method of producing a rapid and pronounced loss of plasma volume in an experimental animal without complicating hemorrhages. Thawing is complete in one to one and one-half hours at room temperatures, and the procedure leads regularly to severe and fatal shock within six to twelve hours according to Muirhead.

From the above it is readily appreciated that *freezing kills living tissue* and, therefore, in warm-blooded animals the reaction of tissue to freezing is for the most part irreversible.

### REFRIGERATION TECHNIC FOR AMPUTATION

The general technic for amputating a limb using chipped ice and tourniquet for anesthesia has been well outlined by Edgar Haley of Baltimore. A well designed metal box such as the Gordon or Haley model is almost an essential (Fig. 134).

Haley's technic is as follows:

"After insertion of the patient's leg, the box is placed on a rubber sheet. The patient's buttocks are supported and raised by a rubber

covered pillow. The head of the bed is raised on six inch shock blocks to keep the patient's leg well in the box and also to allow moisture which condenses on the outside of the box to drain off the foot of the bed. A small piece of rubber sheeting is cut with a hole left which fits loosely around the patient's knee and yet blocks

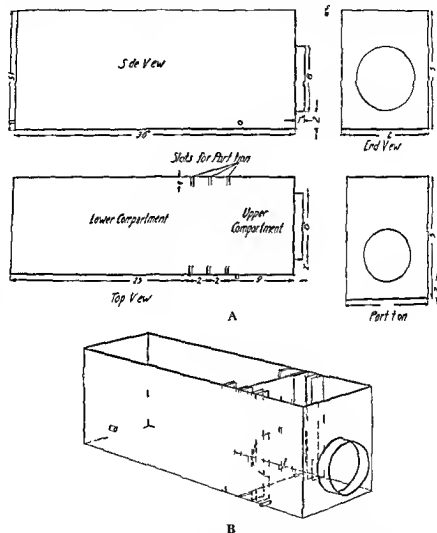


Fig 134—Diagram of metal icing box (After Haley's design)

the hole in the partition of the box enough to prevent ice from falling through to the upper compartment. A second piece is fashioned for the upper part of the thigh to block the hole in the end of the box. Finely chipped ice is now added to the lower compartment covering the leg to the knee.

"A half-hour later, when the leg is well numbed by the cold, a tourniquet of good quality gum tubing is placed about the leg at the level of the tibial tuberosity so that ice extends one or one and one-half inches above the tourniquet. This tourniquet should be put on as tightly as possible because the blood supply must be interrupted completely."

Haley has maintained this state for as long as ninety-six hours, although he states that forty-eight hours is nearly always sufficient to bring the patient to optimum condition for amputation. During this period general supporting measures are applied as indicated.

"Six or eight hours prior to the time for operation the upper compartment is filled with ice, which should reach to the upper third of the thigh. A half-hour later a second tourniquet is tied tightly about the thigh one inch below the line of chilling and yet definitely above the prepared operative field. This tourniquet must be tight enough to occlude the arterial supply unquestionably or anesthesia will not be complete. Amputation is performed between the two tourniquets, which are left in place, the anesthesia lasting for at least an hour and a half. After operation a thin dressing is applied to the stump which is then covered with bare ice bags for twenty-four hours. The patient does not have any meals deferred, pre-operatively or post-operatively, and is permitted to sit up in a chair for an hour on the day of operation, after the procedure."

The details of Haley's management depend on the urgency of the patient's condition:

1. "If gangrene is well established in the foot with a spreading cellulitis and the patient is in a toxic condition he obviously will benefit from an immediate physiologic amputation. Then for forty-eight hours general supportive measures can be carried out with the patient physiologically free of the offending limb.

2. "On the other hand, if there is no infection present and the patient is in relatively good condition amputation does not constitute an emergency, and if the ice-tourniquet technique is to be used in order to minimize the general operative depression it need be applied for only a few hours prior to the time of operation.

"When the limb is first chilled it aches moderately for ten to fifteen minutes, but no patient has complained more than just to mention it. In cases in which there is severe pain from gangrene, the ice affords a definite relief."

#### USE OF THE TOURNIQUET

Because tourniquets offer tremendous advantages in all extremity surgery and since they are essential in obtaining anesthesia by cooling, their application should be understood and they should be used. They should not be feared and thus avoided.



The purpose of a tourniquet is to prevent any arterial blood from reaching the part distal to the tourniquet. In doing this there should be no damage to the soft parts from the application of the tourniquet. If the arterial blood is prevented from reaching the part to be chilled cooling of the part is rapid and complete. Anesthesia is then well established and is maintained. The tourniquet itself contributes to the anesthetic effect.

Tourniquets are safe when properly applied, properly maintained and when removed within the time marking the margin of safety. Tourniquets will cause severe damage from being applied too tightly or by allowing arterial blood to leak past the constriction.

To avoid too tight tourniquets certain principles must be adhered to and not varied at any time under controlled and usual conditions. *For the upper extremity* a blood pressure cuff should be the only type of tourniquet permitted about this member. This cuff can be applied about the arm or forearm. Pressures to 350 millimeters of mercury are safe and can be maintained for up to eighty minutes with safety. The disadvantage of a blood pressure cuff is that it may leak or creep thereby diminishing pressure and allowing the arterial blood through. These disadvantages are easily overcome by either purchasing the type of cuff that cannot creep, or wrapping the ordinary cuff with gauze bandage over which adhesive is wrapped after the cuff is applied to the extremity and before it is inflated. The inlet and outlet tubes are then crimped and clamped. If the air bag is intact pressures are maintained. The anesthetist watches the gauge closely and keeps the pressure up to the desired level.

*For the lower extremity* all tourniquets should be placed about the mid or upper thigh. These tourniquets may be either the rubber strap Esmarch type wrapped layer on layer over three thicknesses of toweling or the pneumatic cuff type. It is almost impossible with any care, to get a tourniquet tight enough to cause real damage when applied about the middle or upper thigh. This is not the case with the arm. Tourniquets may be left on the lower extremity up to two hours with safety but this length of time is rarely necessary. The rubber bandage or Martin bandage is not as satisfactory a tourniquet as the strap with the chain on it. Pressure is harder to judge with these and often they may be too loose and fail.

No tourniquet should be applied to a normal limb without first draining the limb of its blood. In cases of infection or malignancy elevation of the member for a few minutes before application of the tourniquet is all that should be done. With normal extremities the limb should be elevated and then firmly wrapped with some sort of an elastic bandage beginning at the tip of the extremity and carrying the wrapping up to the tourniquet site. After the tourniquet is applied the wrapping is removed. If a pneumatic tourniquet is used

one will note the pressure dropping to quite an extent as the elastic bandage is being removed. The tourniquet should be returned to its former pressure.

When the skin or tissue is incised a bloodless, dry, white field should be expected. The drops of blood in the small arteries or veins that are extruded when these vessels are cut should be red not blue or black. If the latter color is present or oozing of blood of a darkish hue occurs, the tourniquet is leaking and should be removed immediately. A leaking tourniquet can and will at times produce all grades of damage from a mild transient paralysis to a severe permanent paralysis and wasting similar to that of Volkmann. The reason for this is that a leaking tourniquet allows arterial blood through but occludes the venous return. Gradually the capillary bed is dilated to its capacity by arterial pressure. The capillaries then burst and multiple small hemorrhages occur throughout all the tissues. This produces an overwhelming reaction, destroys tissue and can lead to a withered, useless limb.

In Halev's technic of cooling limbs it is noted that he advises the second tourniquet be applied six to eight hours before amputation. This according to Halev, has produced no ill effects. Here we witness the clinical application of the following experimental work.

In 1937 Allen showed experimentally that cooling limbs subjected to local asphyxia by tourniquet or by ligating great vessels greatly prolongs the time a tourniquet can be left on a limb with resultant recovery when the constrictor is removed.

In 1940 Brooks and Duncan showed that gangrene always develops in a rat's tail subjected to pressure of 130 mm of mercury for eighteen hours at room temperature whereas at 33 degrees F it fails to undergo gangrenous changes even after ninety-six hours of the same pressure.

During 1941 I presented a case of bilateral traumatic amputation through the thigh treated by chipped ice. In that paper another case was cited of gangrene of the leg treated by cooling with ice and tourniquet, followed by amputation through the thigh, using no other anesthetic than that produced by chilling. In the latter case operation was done in the late summer of 1939 by Dr. McMahon at the Boston City Hospital.

During 1942 I presented additional cases of cooling limbs for various periods of time. In this paper it was brought out that cooling could be maintained for weeks without injury to the normal skin and without pain or discomfort to the patients. No tourniquets were used on these patients in conjunction with cooling. Each patient was given a general anesthetic and amputation was performed at the site of election using a tourniquet during the operation. There were no deaths and no complications.

## USE OF MACHINE FOR COOLING

About two and one-half years ago I was furnished a machine to replace the use of ice in the cooling of limbs. This machine will cool to  $10^{\circ}\text{F}$  above zero. It is electrically driven, is practically noiseless and is portable. The attachments are of rubber tubing held by a material that is shaped to various parts of the body. Through the rubber tubing the cooling fluid circulates.

It is only necessary to wheel the machine to the bedside of the patient, place the affected extremity in a layer of thin towels or gauze, wrap the flexible attachments about the limb over the towels to the limit of the area selected (Fig 135), adjust the gauge to the



Fig 135 Cooling machine (Therm O Rue) with attachment about leg. Under actual conditions another jacket is placed about the foot. Exposed in illustrations to show touching between skin and cooling jacket.

temperature desired and turn the machine on. Since the temperature is lowered gradually the shock of ice therapy and the discomfort of the first few minutes experienced by patients under ice are eliminated. The problems of nursing care are greatly reduced in magnitude and number.

## MODIFIED AMPUTATION PROCEDURE

Two years ago upon observing cases of traumatized or infected extremities subjected to cooling, I was forced to the opinion that the great service given by cold to these patients lay in the ability of cold to reduce absorption of toxins, to hold infection in abeyance, to eliminate or greatly decrease pain and to prevent and combat shock. These

factors take away all emergency indications for amputation in these patients. There is no need to hurry in any case and time is gained for the patient to rid himself of his toxins, to greatly improve generally, to be stabilized and built up to a point where he can stand a carefully selected general anesthetic and amputation with ease. In other words, a patient admitted in poor general condition with, for example, an infected gangrenous limb, diabetes, and who is somewhat disoriented, has in this writer's opinion the best chance of survival if infection is held static, absorption of toxins prevented, and pain eliminated till the diabetes is controlled and the patient is oriented, active and cheerful. At this time, and only then, a general anesthetic by vein or inhalation or both is given and a planned deliberate operation performed.

To take this same patient in, cool his limb for an hour or more after applying a tourniquet, and amputate as an emergency as soon as the cold has produced sufficient anesthesia by itself, does not appeal to this writer as sound surgical practice. There are many situations where this latter procedure is sound, but whenever operation can be postponed to give time for fortifying the patient by drugs, blood, fluid and chemotherapy, it would seem this should be the procedure of choice.

For these reasons we have not used tourniquets for our cases except at time of surgery. The gradual evolution of our routine, using the Therm-O-Rite machine, has led us in the last two years to amputate by cold. This is done by preparing the limb as previously described and taking the temperature down to 10° F. above zero. The portion of the limb involved is frozen solid. Patients have been kept in this condition for as long as eight weeks. During this time they are comfortable, and the leg for all practical purposes is amputated.

Technic.—On the day of surgery, the apparatus is removed about twenty minutes before operation, the towels are left about the limb, the remaining portion of the extremity is thoroughly washed with soap and water, using cotton pledgets, for a period of ten minutes by the clock. The whole limb is now draped in sterile towels. The patient is put to sleep. The limb is elevated, the tourniquet is applied, and then the limb is surgically prepared and the operation is begun. In severe arteriosclerotics, a tourniquet is sterilized and put about the thigh but not tightened. It is used as a constrictor only at the time of severing the large vessels and while ligating them.

No catgut larger than double zero is used. Drains are not permitted. One layer of gauze is placed over the wound and fastened on each surface by a postage stamp size of adhesive tape. Moleskin traction straps are placed high on the limb and end in a block, through the center of which is the traction rope. This all is covered with a snug fitting stockinet which is tied about the rope just after its exit from the block. The patients are put to bed with 2 pounds of traction on this rope and with slight elevation of the limb.

On the second day after operation the patients are allowed up in wheel chairs. The sutures are removed on the twelfth day.

Under this routine there have been no deaths before at or after operation. All wounds have healed by primary intention without in duration drainage or slough. The one case not closed primarily was a case of overwhelming staphylococcus infection where freezing was carried to about 3 inches below the hip. A guillotine type of amputation was used here. Healing was slow but was obtained.

One of the interesting features of freezing limbs is that although one might expect a line of demarcation with consequent slough, pain, etc. at the site where the normal portion of limb meets the cooling jacket this does not occur. There is a definite area of ecchymosis about 2 inches wide just proximal to the cooling jacket but this does not break down or cause any discomfort. We have had repeated temperature readings performed by Dr. Osborne of the Northwestern University Department of Physical Therapy and the temperature grades to normal gradually without the so called bite back giving any trouble. It is of course practically certain that if one should allow the cold portion of limb adjoining the frozen part to remain it would be dead. This we have not done.

*General Anesthesia and Cold*—It is my opinion that the least important part of cold therapy is the ability it gives to amputate without any other anesthetic. The great forte of cold therapy is the *painless physiologic amputation* it achieves without any risk to the patient. The patient then responds and can be prepared for a general anesthetic which under modern control carries little risk. We have used pentothal sodium as a routine for induction and then the patient is carried on 60 per cent nitrous oxide and 40 per cent oxygen. The inhalation anesthetic is reinforced with pentothal if needed throughout the operation. Under this routine we have had no trouble with the anesthetics in any elderly patients.

#### OTHER USES FOR COLD

The use of cold for anesthesia except in certain emergency cases is finding wider application in *minor surgery*. It seems to this author that here the anesthesia produced by cold is more practical. Some of the applications that have been proven satisfactory when properly performed are as follows:

1. Dr. Harry Mock and others have used cold (ice packs) for anesthesia in obtaining skin grafts.

2. Dr. Hallev Friederwitzer has used ice to obtain anesthesia for surgery on infected toenails, carbuncles, paronychia, abscesses near the skin surfaces, skin growths such as nevi and in certain dislocation and fractures such as of the wrists, fingers and elbows.

Ernst Dehne has found what he feels is a valuable use of cold in post

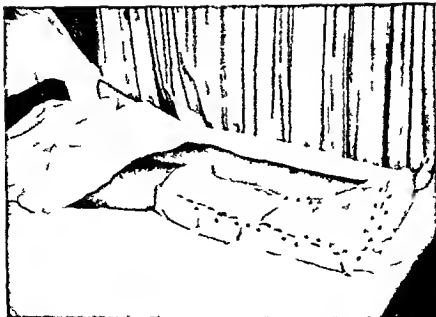


Fig 136—Super Ice pack applied in foot form. Various sizes and shapes have been designed for different parts of the body

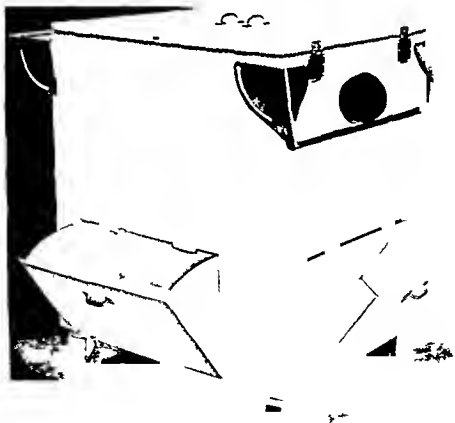


Fig 137—Machine to cool Super Ice packs. Machine has capacity to 25° below zero Fahrenheit.

operative treatment of extremity surgery After operation, a *ring of cooling material* is placed completely about the limb 4 to 6 inches proximal to the operative site This, in addition to ice packs about the operative site, has in his opinion, markedly lessened pain and has greatly decreased muscular spasm If motion of the part, either active or passive, is desired it is, according to Dehne, achieved more readily and with very little discomfort to the patient

**Super Ice**—Since cooling of many parts of the body has been long accepted as good therapy in certain conditions it would be valuable if some way could be found either to eliminate ice or to preserve it for longer periods of time In this way frequent changes of ice, chipping, transportation and the nursing care of the patient would all be decreased For this purpose we have been furnished with a material known as Super Ice This is a light absorbent material that is saturated with a mixture of salts It is then cooled to any temperature below freezing that is desired When this material is placed about ice the ice lasts much longer These packs can be used also on the patient without ice They are fashioned to fit various parts of the body The machine for preparing the packs and some of the Super-Ice packs are illustrated (Figs 136 and 137) Work on this material is in progress but has not advanced far enough to warrant definite conclusions

### CASE REPORTS

The following case histories are presented to illustrate different conditions where cooling or freezing of limbs is felt to be of great advantage

#### Case I To Illustrate the Effect of Cooling in Diabetic Gangrene

A white man aged 76 years was admitted to Boston City Hospital in the late summer of 1939 This man was diabetic and his diabetes was uncontrolled He was delirious and had a high fever from an infected gangrenous left foot of about three weeks duration His condition was so poor that surgery was not considered as it was felt he would not live under any condition The limb was surrounded by ice to the mid thigh Twenty four hours after the application of the ice a tourniquet was placed tightly about the thigh just below the site of proposed amputation

Instead of getting worse this man began to improve markedly Forty eight hours after the chilling was started his condition was fair He was given supportive therapy, his diabetes was controlled his blood nitrogen decreased and after five days of chilling with the tourniquet left intact his condition was so improved that he was amputated just above the tourniquet site with no other anesthesia than that provided by the chilling Recovery was uneventful

#### Case II To Show the Effect of Cooling Traumatized and Potentially Infected Limbs

The morning of November 30 1940 I was called to see a man aged 50 years who one hour previously had been run over by a railroad train which had am

puted his left leg just above the knee and his right leg through the knee joint. The man was lying on the floor of the emergency room when I first saw him.

The house surgeon at West Suburban Hospital had applied tourniquets about the thighs. The man was bled out and was in profound shock. His blood pressure was 30/0. He was receiving 1500 cc of gum acacia through the veins of both arms. As soon as possible whole blood was given because it was felt it would be more beneficial than blood serum. The tourniquets were released and all bleeding points were seized with hemostats which were left in place. The tourniquets were left around the thighs in case they were needed. The stumps were wrapped in gauze soaked in a solution of sulfanilamide. Two hours later the patient's blood pressure was 40/0. Eight hours after injury his blood pressure was 50/10.

The day of the accident was slushy and because of the sudden application of the train's brakes the under carriage of the cars had rained snow, mud and sand over the limbs. This material was ground up and mixed with clothing, huge flaps of skin, muscle and bone. The ends of the stumps were ragged and extensively macerated.

Ten hours after injury the patient complained of pain in the left chest. He was irrational and was tossing from side to side complaining of pain in his feet and legs. An electrocardiogram showed sinus tachycardia. His blood pressure remained about the same.

Twenty hours after injury a pronounced foul odor was emanating from the stumps. Large doses of morphine were needed to control him. He was coughing and was irrational. The blood pressure had shown no rise. A consultant confirmed the diagnosis of pneumonia and sulfapyridine was substituted for the sulfanilamide he had been getting. He still received neoprontosil. His temperature was 101.4° by axilla.

It was evident that nothing at this time could be done for the patient's lower extremities. The gauze was removed from the stumps and they were completely enclosed in shaved ice to 2 inches above the extent of tissue damage. No tourniquets were applied. Within one hour following the application of the ice all pain ceased in the lower limbs. Soon the foul odor from the stumps vanished. The patient became quite rational and it was possible to take his temperature by mouth. The icing profoundly affected his temperature which fell to 97.2° by mouth. Heat blankets were applied over the patient's body and his temperature again rose to around 101.0° by mouth. Supportive treatment was given including blood. He was given three successive prophylactic doses of combined sera.

On Monday afternoon, December 2, fifty-eight hours after injury, the patient's condition had markedly improved. Blood pressure was 110/60. Fever was 101° by mouth. The pneumonia was not progressing. At this time the patient was taken to the operating room and under ethylene anesthesia both lower extremities were elevated, high tourniquets were applied and a simultaneous bilateral amputation was done. On the left side the site was through the midthigh and on the right side the site was through the lower third of the thigh. A "fish mouth" type of incision was used. The muscle jumped and retracted smartly. The flaps were allowed to fall together. Soft rubber drains were inserted and a few loose silkworm sutures were used to gently approximate the flaps. There was no redness, induration or ecchymosis of either thigh at or below the site of amputation. During operation blood pressure fell from 110 to 105. He was transfused on the operating table.

The day following operation the patient broke into a profuse sweat. His fever dropped by crisis to normal. His chest condition rapidly resolved. Since that time the patient's recovery has been uneventful. His fever never exceeded 100° by mouth and after the sixth postoperative day it was normal. Five days



after operation the patient was sitting up in bed reading a paper and smoking his pipe. The stumps were healing well with no signs of induration, infection or slough of skin or other tissue. Drainage from both stumps was diminishing and at the end of six weeks both stumps were practically healed.

The appearance of the amputated parts was interesting. They were cold and firm. There was no gross evidence of infection or inflammation. The muscle was red and healthy looking. The fascia glistened. There were no blood clots. This was probably due to the washing achieved by the melting ice. The blood was red and fresh looking. The mud and sand were moist and looked as they had the day of the accident. The particles of sand stood out in bold relief on the surface of the tissue with no signs of sticking to the tissue as is so often seen in wounds that are softened by disintegration of tissue. The subcutaneous fat was firm. There was no odor except from a few soft bluish white tags of skin which had not been included in the ice.

*Comment*—This case is presented because it is believed that beneficial effects, both general and local, were obtained by the application of Allen's principles to a severe traumatic injury, also to bring forth the fact that cooling was used not to preserve a portion of a limb but to prevent the development and progress of bacterial infection and invasion in heavily contaminated and potentially infected wounds.

The purpose was to *obtain time* in which the patient's general condition could be improved sufficiently to permit major surgery. In this case fifty-eight hours elapsed between the time of accident and the surgical amputation of both limbs through the thigh.

This case does not permit one to say whether the oral sulfapyridine, the intramuscular neoprontosil, the local sulfanilamide or the local icing was the determining factor in the result. The lack of cultures taken from the wounds limits effective discussion. It would seem, however, that icing did stop local pain, did materially aid the patient in combating shock and did stop all odors emanating from the stumps. The patient's improvement was remarkable following the application of the ice. The pieces of skin not included in the ice were gangrenous while equally detached pieces of skin included in the ice were well preserved. Physiologically and bacteriologically the procedure would seem to be sound.

If upon continued investigation these findings are confirmed the method of cooling limbs advocated by Allen might find wide application in severe wounds in both civil and military life. This cooling might be effected by ice or gas. It would be of use not only in extremities that might be saved, but it would be of value in holding infection in abeyance in hopelessly traumatized limbs or parts in those cases in which surgical aid is not immediately forthcoming either because of the patient's condition or because of the circumstances under which the accident occurred.

### Case III. To Illustrate the Length of Time that Cooling Can be Applied without Damage to the Skin

A 70 year old man, who had gangrene of the right foot and ankle with severe pain, was admitted to West Suburban Hospital in poor condition. He was irrational, noisy and a morphine addict. His craving for morphine, according to him, was due to the severe pain he suffered in his leg. Previous to admission the gangrene had been dry, but two days before admission a rapid ascension of the gangrene had occurred of the wet type. It was necessary to place him in restraints to keep him in bed.

This patient's right limb was encased in shaved ice to above the middle of the calf. This allowed the ice to extend approximately 5 inches above the extent of gangrene. Soon after icing, pain in the limb disappeared. The patient complained at times of a cold sensation at the juncture of the ice and the normal part of the limb. This patient was kept constantly in ice for twenty eight days with no damage to the normal skin enclosed in the ice. A mid thigh amputation was then done, and recovery was uneventful.

*Comment*—The question of how long normal skin can stand the application of ice without showing disintegration has been in interesting speculation. It has been shown by many workers that, following the removal of ice, the reaction of the chilled parts is marked. The resistance of the tissue is greatly lowered and healing is retarded. It has been desirable, however, to find out how long skin could stand constant cold and maintain its vitality in a part to be amputated.

No tourniquet was applied at any time in this case, except at amputation. After the first few days of icing, the only medication that the patient received was 5 grains of aspirin at bedtime. He became thoroughly rational, was able to enjoy his food, read papers and books, to shave himself, and to all appearances was comfortable and happy. His temperature, which had been high on admission, dropped to normal and remained so. The gangrene did not progress. There was no odor discernible. His friends and relatives visited him regularly, and they stated that as far as they could tell, he was perfectly oriented.

This case, then, is presented to show that cooling without tourniquet can, by lowering the metabolism of a part, prevent the absorption of toxin and the advance of bacterial infection, and can relieve pain. It further shows that in parts to be amputated it is possible, if the cooling is constantly maintained, to continue icing for long periods of time without pain and without damage to the parts.

### Case IV. To Illustrate the Effect of Freezing a Limb in Infected Gangrene of the Foot and Leg

A white man aged 72 years was admitted to Wesley Memorial Hospital on January 2, 1943. He was in poor condition. He was disoriented and thrashed about in bed. His left foot and leg to about 4 inches below the knee were gangrenous, wet and draining. There was a foul odor emanating from the ex-

tremity. He was not diabetic. The right foot had no dorsalis pedis or posterior tibial pulsations.

Four hours after admission the freezing jacket was applied to his limb from the toes to the knee. The leg was amputated by freezing the extremity at 10° F above zero. Two days after freezing the limb, the patient was comfortable.

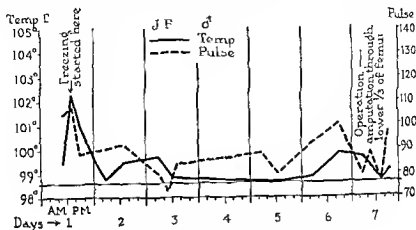


Fig 138—Effect of freezing the extremity in Case IV

and improving. The chart illustrates his course (Fig 138). At time of operation his condition was excellent. A general anesthetic was given. Amputation was performed and recovery was uneventful. No tourniquet was used.

*Comment*—Cases have been kept frozen by us for as long as eight weeks. This was done to note harmful effects on the patients and to see how uncomfortable they would be. The patients have been comfortable, bright and cheerful. No harmful effects have been noted.

#### Case V. To Illustrate the Effect of Freezing on Overwhelming Infection of an Extremity

A white man aged 65 years was admitted to Passavant Memorial Hospital. A Kirschner wire had been inserted into the lower third of the femur and had pierced a blood vessel. This area developed a mixed staphylococcus and streptococcus infection. A phlegmon of the whole leg developed extending to the groin. An abscess was present involving the lower half of the thigh. This was incised and drained.

Soon afterward profuse hemorrhage occurred which resulted from rupture of an aneurysm of the femoral artery. A tourniquet was put about the thigh to control the bleeding. The patient's condition was critical. Two days later his condition had not improved and it was felt the absorption of toxins and the advance of infection in spite of chemotherapy would prove fatal.

On January 28, 1943, the entire limb was frozen from the toes to just below the groin. The effect of amputation by freezing is shown in the accompanying chart (Fig 139). Nine days after freezing a guillotine type of amputation was done. A general anesthetic was given. Healing of the stump, which was above

the upper third limit of the femur, was slow but was obtained. The man eventually fully recovered.

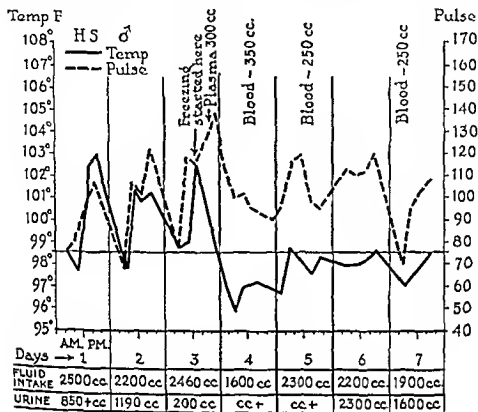


Fig 139—Effect of freezing extremity in Case V

**Comment**—The great service of cold here, we see again, was in combating absorption and infection. This gave time to improve the patient to the point where operation could be tolerated with ease.

#### Case VI Effect of Ice on a Crushing Injury

A 69 year old man was caught between a locomotive turntable and a concrete wall crushing the right leg from below the knee to the metatarsals and the left leg from 2 inches above the ankle to the metatarsals. On admission to Passavant Memorial Hospital there was a compound fracture of the tibia in the lower third with a fracture of the internal malleolus on the right. Further, the skin was avulsed from the lower third of the tibia and turned back over the heel and foot with severe crushing and maceration of the skin over the entire tibial surface. The ankle joint was exposed. On the left, the skin was avulsed from 2 inches above the ankle down over the heel and turned back over the foot. With this was carried the short foot extensors.

The x rays showed extensive calcification of the leg vessels.

Grossly all wounds appeared clean. They were debrided and the skin flaps were sewn back into place and mild compression bandages were applied. A plaster mold was applied to the right leg.

The patient was placed on sulfa therapy and a blood level of 103 mg was obtained and maintained. In spite of this the patient ran a septic fever with

peaks of 101° to 102° F up to the tenth day. At this time some of the skin on the left showed areas of demarcation with no evidence of infection.

On the right some areas of skin were blanched and depressed others were gangrenous. Extensive bleb formation was present. Serosanguineous drainage was encountered in large amounts. The whole leg was markedly swollen. Circulation and motion were present in the toes. At this time amputation of the right leg was advised.

Preparatory to amputation the leg was packed in ice. No tourniquet was applied. The fever immediately began to drop and within eight hours the temperature was normal. Two days later the sulfa therapy was discontinued but the temperature remained normal.

Part of the discolored skin which had appeared gangrenous returned to normal. The remaining gangrenous skin was removed. Healthy granulation developed in these areas and these were covered by split skin grafts.

The patient was kept for eight weeks in ice. The skin grafts grew satisfactorily even while the patient was in ice.

Four months after injury the patient started vomiting, became comatose and died within a few days.

Postmortem examination revealed a subacute yellow atrophy of the liver as the cause of death.

Dissection of the right leg revealed that the fractured tibia had healed by bony union in malposition. Between the fragments of the fibula there was a well walled off small abscess. The ankle joint which had been widely exposed at injury showed no evidence of sepsis. The muscles of the calf showed extensive fibrotic changes. The skin had normal appearance and the grafts had taken.

*Comment*—This is a case in which a crushing injury was superimposed on primary arteriosclerotic limbs in which circulation was at least somewhat impaired.

The circulation proved inadequate to supply the local metabolic demands of the tissue and provided an inadequate resistance against infection. Maintenance of an otherwise adequate sulfa level was inadequate in combating the infection.

It is believed that the lowering of the tissue demands through cooling enabled the impaired circulation to supply the part adequately and thus overcome the infection and to institute the reparatory processes.

### CONCLUSIONS

The use of cold as a therapeutic agent has wide application. Very little is known of the effect of cold on tissue from a pathologic and physiologic viewpoint.

It is believed that cold therapy is here to stay as an adjunct in the treatment of various conditions. The greatest value to date lies in the ability of cold to decrease absorption, hold infection in abeyance, combat shock and to diminish or abolish pain.

Further, we suggest that in cases of malignancy the freezing solid of the part before amputation or resection is done might offer beneficial effects by preventing implantation or spread of malignant cells.

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## CLINICS ON OTHER SUBJECTS

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### THE EFFECT OF PENICILLIN IN CARBUNCLE OF THE KIDNEY

#### A Case Report

ROBERT W McALLISTER MD, FACS \* AND VINCENT J O'CONNOR MD, FACS †

CARBUNCLE of the kidney has been considered a rare condition. In 1932 one of us reported two instances and after a thorough search of the literature, found only ninety two other cases reported. Since that time about 100 additional observations have been recorded. On our own service, including the patient herewith presented, we have operated upon nine patients with carbuncle of the kidney during the past thirteen years.

Since this lesion is apparently always hematogenous in origin and secondary to a previous staphylococcus focus elsewhere in the body we were eagerly awaiting an opportunity to use penicillin treatment in the hope that spontaneous healing of the massive parenchymal infection might be effected and a cure obtained without the necessity of surgical intervention.

Such an experience is herewith reported and none other has as yet been brought to our attention.

#### CASE REPORT

E. G. a white man aged 46 entered Wesley Memorial Hospital under the care of Dr. Arthur L. Mable on May 15, 1944. He complained of weakness, backache especially in the left flank, nausea, anorexia, constipation and abdominal distention. Just prior to admission he had vomited three times and had noted gross blood in the urine. He had not moved his bowels for three days.

Two weeks prior to admission he became ill while at work and was sent home with a temperature of 103° F. His only complaint at this time was a vague pain in the abdomen and legs. His physician diagnosed an upper respiratory infection and confined him to bed. He continued to feel ill and to run an intermittent fever until admission to the hospital. He had no knowledge of any recent cutaneous infection such as a boil, a phlegmon or a paronychia.

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On admission the patient did not appear acutely ill. Temperature was 99.4° F., pulse rate 70, blood pressure 138/70. The chest was clear and there was no sign of an upper respiratory infection. The abdomen was moderately distended but not tender (fig 140). There was exquisite pain and tenderness over the left lumbar region with marked muscular spasm. The right lumbar region was relaxed and not tender. The urine was grossly bloody, was alkaline in reaction, specific gravity 1.070, no sugar, albumin 4+, centrifuged specimen showed many erythrocytes and only an occasional leukocyte. Blood count showed erythrocytes 4,460,000, hemoglobin 87 per cent, leukocyte count 20,700 with 86 per cent neutrophils, 5 per cent lymphocytes, 1 per cent eosinophils, 8 per cent monocytes. Sedimentation rate was 19 mm in one hour. Kahn reaction was negative.



Fig 140



Fig 141

Fig 140—X ray findings on admission showing marked bowel distention.

Fig 141—The pyelogram shows an enlarged renal shadow with retraction and narrowing of the middle and inferior calices and a 'cup'-shaped deformity of the minor inferior calyx.

The blood nonprotein nitrogen was 45.8 mg per 100 cc. A throat culture gave a moderately heavy growth of *Streptococcus viridans* but no staphylococci.

On May 16 the temperature arose to 102.8° F with pulse increasing to 120 (Fig 142). Some relief was experienced with enemas and bowel cleansing but the patient's abdomen remained distended and he had no appetite. Evacuation programs were made but these were unsatisfactory due to the marked abdominal distention. This procedure was followed by a heavy rash about the face and neck which was presumed to be due to an allergic reaction to the iodide. On May 17 the temperature rose to 103° F and the pulse to 125. The urine at this time had become grossly clear.

Cystoscopic examination was done on May 18th. The urethra and bladder neck were normal. The prostate, as felt per rectum, seemed normal in every



respect. Aside from a mild hyperemia of the mucosa, the bladder appeared normal. Both ureters were easily catheterized 30 cm with No. 6 F catheters and a normal flow of grossly clear urine was obtained from either kidney. Phenolsulfonphthalein given intravenously appeared in three minutes from each kidney and was excreted in good concentration on both sides, although somewhat less concentrated on the left. Scout films with catheters in situ showed nothing abnormal. Right pyeloureterogram was normal in all respects. The left pyelogram showed an enlarged renal shadow with retraction and narrowing of the middle and inferior calices and a 'cup' shaped deformity of the minor inflexion calyx (Fig. 141). These outlines suggested a mass within the substance of the lower polar region of the left kidney. From a pyelographic point of view this deformity suggested a differentiation between neoplasm or massive infection of the renal parenchyma.

Cultures of the urine from either kidney showed no growth in forty-eight hours. Culture of the bladder urine returned a moderate growth of *Staphylococcus albus*.

A diagnosis of carbuncle of the lower pole of the left kidney was made and medical treatment with penicillin was advised. Two hundred thousand units were given intravenously during the first twenty-four hours. For the next forty-eight hours 20,000 units were given intramuscularly every four hours until a total dosage of 360,000 units of penicillin had been administered in three days.

The accompanying charts show the course of the temperature throughout the patient's clinical course (Figs. 142, 143 and 144).

Forty-eight hours after the institution of penicillin therapy the patient's temperature returned to normal, the leukocyte count fell to 12,450 and the patient's general condition improved in a spectacular manner. The severe pain and tenderness in the left loin almost completely disappeared, the abdominal distention was relieved, the appetite returned to normal and the bowels moved satisfactorily. The urine remained grossly clear and contained no albumin and only a rare pus cell was seen in the centrifuged specimen.

This improvement continued for five days. On the fifth day (after completion of penicillin treatment) the temperature rose to 100.2° F and on the sixth day to 102°. The leukocyte count rose to 27,600. On May 26 the voided urine became turbid and filled with yellow purulent material of pus, mucus and debris. Examination of the left loin showed an increased pain and tenderness with marked spasm of the left lumbar muscles.

This change in the clinical course suggested to us that the carbuncle had ruptured into the left renal pelvis and the patient's condition was becoming increasingly unsatisfactory.

The second cystoscopy was done on May 27 and only the left ureter was catheterized. The urine from the left kidney was thick, yellow and purulent. Phenolsulfonphthalein injected intravenously appeared in eight minutes and was excreted in 3 plus concentration over a period of fifteen minutes. Eight cubic centimeters of 12 per cent

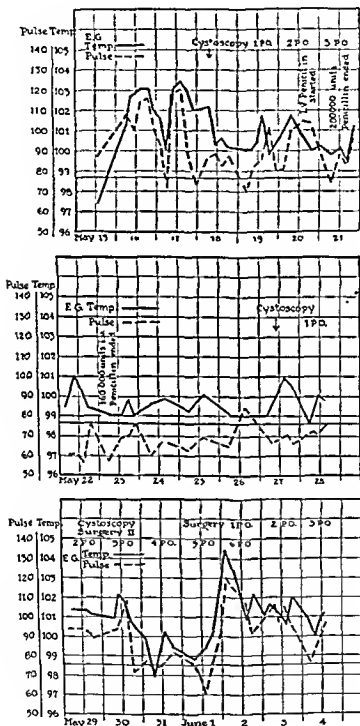


Fig. 142.—Clinical course.

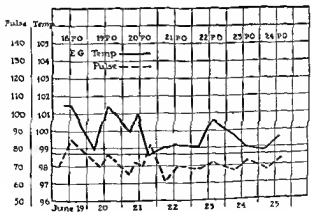
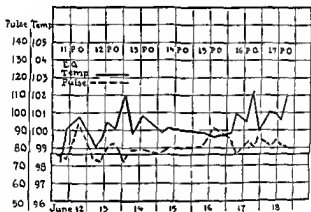
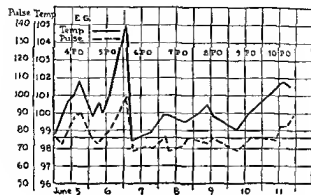


Fig 143—Clinical course (continued)

sodium iodide solution was injected slowly into the left kidney and the resulting pyelogram showed a wide moth-eaten type of defect involving the area of both the middle and inferior calices. This outline

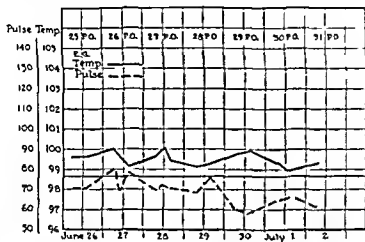


Fig 144—Clinical course (concluded).



Fig 145—The pyelogram after penicillin therapy, showing a wide moth eaten type of defect involving the area of both the middle and inferior calices

suggested an apparent partial liquefaction of the carbuncular mass with the resultant puddling of the opaque material within the middle and lower calices of the left kidney (Fig 145)

This condition was considered unsatisfactory and while the patient was in much better general condition than prior to penicillin therapy the clinical signs and symptoms were again increasing.

A renal exploration for drainage of the carbuncle or possibly left nephrectomy was decided upon. This procedure was done on June 1, 1944 under spinal anesthesia. There was no evidence of perinephric abscess and the renal capsule was intact. The perinephric fat was densely adherent to the kidney at the lower pole and about the hilus of the kidney. Palpation of the freed kidney suggested a large mass within the substance of the kidney. A left nephrectomy was done without spilling any infected material in the wound and with very

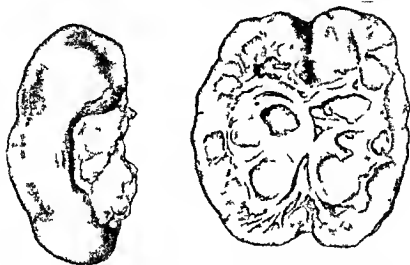


Fig 146—A drawing of the kidney before and after sectioning showing the confluent carbuncular craters.

little hemorrhage. The renal fossa was drained with three split rubber tubes and the muscles closed in the usual manner. The patient left the operating room in good condition.

The kidney was sectioned after removal and was found to be filled with thick yellow pus having the odor and appearance usually encountered in a lung abscess. The lesion seemed multiple and was as grossly that of two confluent carbuncles which had undergone liquefaction but had left connecting deep rims of infected craters (Fig 146). The complete pathological report of Dr. E. R. Strauser is as follows:

*Gross* The kidney weighs 181 gm and measures 12 by 7 by 4.5 cm in size. It is a grayish tan color on the external surface and a yellowish tan color on the cut surface. The cut surface is pale. Cortical markings are completely ob-

secured The cortex ranged from 7 to 9 mm in thickness There is atrophy of both cortical and medullary portions The wall of the pelvis is greatly thickened and much of the mucosal surface is thickened It is especially thickened at the calices Considerable soft custard like material is adherent at the surface of the mucosa The peripelvic fat is markedly indurated It is markedly adherent about the hollow of the kidney

*Microscopical* Sections of the kidney show rather marked parenchymatous degeneration of the tubular epithelium Most of the glomeruli completely fill the glomerular capsules but there is no capsular thickening and no significant changes in the glomeruli except that some appear to be atrophic

Sections through the wall of the abscessed portions of the kidney show almost complete destruction of the epithelium and a great increase of fibrous tissue within the stroma There is a fairly dense infiltration of lymphocytes eosinophils and neutrophils which is very dense in the lining of the abscess cavities Sections show marked inflammatory infiltration of the pelvic wall most of which consists of pus cells and fibrin The wall is congested in many places There is marked increased density of the peripelvic stroma

*Diagnosis* Carbuncle (with pyelonephrosis)

Following operation the temperature ranged from 98° to 100.3° F (as shown in the accompanying charts) for fifteen days The patient improved steadily but his convalescence was prolonged due to a persistent staphylococcal infection in his wound Two hundred thousand units of penicillin were given intramuscularly for this infection without any noteworthy improvement The wound infection responded best to hot boric compresses and hydrogen peroxide irrigations The wound was completely healed on the thirty first postoperative day and the patient was dismissed on July 2, 1944 He returned to his usual work one month later and his present health is excellent

*Comment*—Before having the opportunity of treating a clear cut case of carbuncle of the kidney with penicillin we had decided that one of three things would happen first, and most to be desired, would be a complete resolution and subsequent healing of the massive parenchymal lesion second dissolution and rupture into the perinephric region with formation of a perinephric abscess which would probably require surgical drainage, third, and least probable, rupture into the renal pelvis with a subsequent pyelonephrosis which would probably require surgical drainage or nephrectomy The last occurred in this instance

The spectacular improvement effected by penicillin in this patient changed his condition so that he became a much more desirable surgical risk It may have prevented the development of other staphylococcal deposits in adjacent or remote parts of the body

It might be argued that continued expectant treatment and perhaps more penicillin should have been administered to this patient before resorting to radical nephrectomy The pathological findings at operation and the subsequent recovery seem to justify our procedure

Carbuncle of the kidney was not a common condition before the widespread use of the sulfonamides It is now the general feeling that

all cortical infectious lesions of the kidney will rarely present a surgical problem when the sulfonamides or penicillin are available. The validity of this premise will only be proved by time and experience. Meanwhile it will be interesting to follow reports on the use of penicillin in the treatment of carbuncle of the kidney. Its use may reduce the necessity for surgery in these cases and as demonstrated by this report a pre surgical remission of clinical symptoms can be produced.

## INGUINAL HERNIA REPORT OF 1126 CASES

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THE medical literature on hernia is voluminous. Numerous articles have been written on the historical aspect, etiology of hernia, technic of hernia repair, and the use of various suture materials.

Herniorrhaphy is one of the most common operations in a Marine Hospital and also one of the most important. A satisfactory result is necessary in order to return the patient to duty and thus preserve military manpower. It is also of national importance from a civilian standpoint. Many of our patients are civilian employees of the Government. Whenever one of these individuals suffers from a hernia, it is estimated that his efficiency is lowered 25 per cent or he is rejected from work until satisfactory repair has been accomplished. Hernia then becomes a problem of great economic importance. This is manifested in various ways. If the employee remains on duty, his output is lessened, he avoids strenuous work, protects himself and thereby lessens the efficiency of his fellow workers. If he is rejected, it becomes necessary to have an operation before he can pursue a gainful occupation or he may become a member of the relief rolls. Some of our beneficiaries are paid compensation during their period of disability. Occasionally it may be necessary to train a replacement man, which is time consuming and expensive. Regardless of how the case is handled, there is always the possibility that it may pass from a local economic problem to one of national importance.

The purpose of this paper is to report on 1126 cases of inguinal hernia. Out of this group we were able to have varying follow up periods in 856 cases. All of the patients were male, most of them seafaring individuals without permanent addresses which has made the follow up rather difficult. The follow up study was carried out by questionnaire encouraging as many patients as possible to report for examination. Subsequent examination of a few revealed a hernia although they had stated on the questionnaire that they were all right, but the reverse was also found to be true in approximately the same percentage of cases.

We also wish to present a technic of repair embodying many principles already advocated which has proved satisfactory. It is the one used most commonly in these cases. It is not our intention to present

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a standardized technic, because we feel that each case presents a problem peculiar to itself. We all know that various individuals present different structural and anatomical arrangements even though their hernias can be classified into certain types. Therefore a thorough familiarity with the anatomy and the carrying out of the cardinal principles of surgery are most important. These cardinal principles are sharp dissection, careful handling of tissue, control of hemorrhage, protection of the wound, proper placing of sutures, and care in tension of sutures, not tying them too tightly. Meticulous technic and care in every detail during the operation are essential for success.

Careful examination of the patient before operation is essential and correction of any condition that may predispose to recurrence should be accomplished. Examination of the inguinal region by the operator is important because this often is of help in deciding upon the method which he will use to fortify the inguinal triangle. The operation should be performed while the operator is fresh and not worn out from a heavy schedule. The economic factor involved is large enough for this consideration.

Postoperative vigilance and instruction to the patient add greatly to the success of the operation. This does not mean that intensive postoperative therapy is necessary—quite the contrary. Only a few simple orders are necessary, some of which the patient himself can carry out to insure a smooth convalescence.

In these cases some comparison can be made in the matter of suture material. Catgut, silk, and fascia were used as suture material. In the catgut series chromic No. 0 twenty days was used in the transversalis fascia, chromic No. 1 or No. 2 twenty days for the repair, and chromic No. 0 or No. 1 in the external oblique fascia. In the silk series No. 2 or No. 3 Champion silk was used for the deep repair and No. 0 or No. 1 in the external oblique fascia. Since this study was made cotton has been used in 250 cases by various operators on the service with no untoward results. Number 30 cotton was used for the deep repair. Cotton was easy to work with and the wounds showed very little induration postoperatively. There were two infections which healed without discharging any suture material.

#### TECHNIC

The general principles of our method include the following:

1. Thorough preoperative examination.
2. Preparation of operative site the night before operation followed by application of tincture of mercuriolate.
3. Occasional delay in cases in which a truss is worn to allow the skin to return to normal.
4. Spinal anesthesia was employed in most instances. Local anesthesia was used in the older age group or poor risk cases.

- 5 Careful operative technic with attention to details
- 6 Postoperative vigilance with stress on deep breathing exercises and exercises for extremities Early catheterization, if necessary but always attempting to train patient to use urinal in bed before operation
- 7 Indirect hernia Bed rest fifteen days with six weeks convalescence  
Direct hernia Bed rest eighteen days with eight weeks convalescence

The older age group are allowed out of bed earlier and more latitude of movement while in bed. This length of convalescence is standard except in a few instances in which the patient is not doing strenuous work.



Fig 147

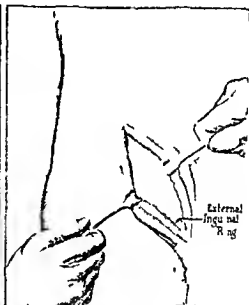


Fig 148

Fig 147—Skin incision showing position

Fig 148—Showing aponeurosis exposed

The technic may be divided into *five steps*

1 *Exposure and visualization of cord and sac* The skin incision is made from the pubic spine upward about 2 to 3 fingerbreadths medial and parallel to Poupart's ligament (Fig 147). The superficial veins are caught between clamps before cutting to prevent their retracting into adipose tissue. The external oblique aponeurosis and external ring is exposed (Fig 148), a close watch being kept for superficial branches of the iliohypogastric nerve. The aponeurosis of the external oblique is then cut along the medial side of the external ring in the direction of its fibers (Fig 149). In doing this, the incision is made in the aponeurosis along the upper edge of the incision and carried down to

the external ring, stripping off the iliohypogastric and ilio inguinal nerve. The latter is often adherent along the lateral side of ring. The cord is then mobilized (Fig 150), after stripping all areolar tissue from the internal and external oblique fascia.

2 *Dissection and exploration of sac* The indirect sac can always be found along the anterior and medial surface of the cord. It is opened not only in indirect and combined types of hernia, but also in simple direct and femoral hernias. We ordinarily do not disturb the peritoneum lateral to the vessels in a direct hernia with a diverticular like sac and a small opening in Hesselbach's triangle. If the indirect sac is long the distal segment may or may not be disturbed. If easily sep-



Fig 149

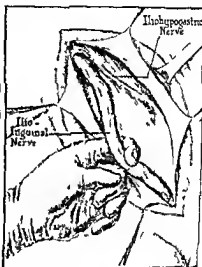


Fig 150

Fig 149 Showing incision in aponeurosis at medial side of external ring

Fig 150 Showing aponeurosis open and spermatic cord mobilized

arated, it is removed, and if large and densely adherent it may be everted around the cord. After opening the indirect sac, exploration is made for direct or femoral sacs (Fig 151). If one is found it is removed.

recurrent direct or femoral hernia. After the indirect sac we do not feel that proper dissection has been carried out unless the bladder is seen and dissected off to allow high closure (Fig 152).

3 *Closure of sac* (Fig 153) In any hernia repair, the manner in which the sac is handled is of prime importance. Careful dissection and high ligation are essential. If the sac is narrow, simple transfixion

and ligation suffices. It may then be transplanted, if so desired, but care should be taken that the lower portion of the transfixion suture is well

Fig. 151.



Fig. 152.



Fig. 153.

Fig. 151.—Showing finger through indirect sac lifting up direct sac and combining into total indirect hernia.

Fig. 152.—Showing bladder being peeled from direct sac.

Fig. 153.—Showing method of purse-string closure of sac.

anchored. If the mouth of the sac is more than an inch in diameter a purse-string suture is used, with transfixion but not transplaatation.

The latter is not necessary or advisable if the sac has been dissected out well. If the mouth of the sac is extremely wide, it is closed like

Fig 154

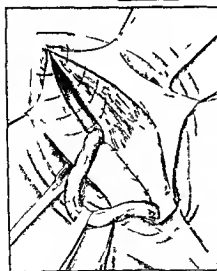


Fig 155

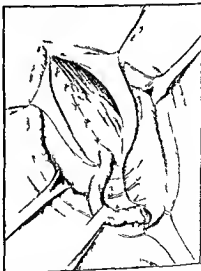


Fig 156

Fig 154—Showing transversalis fascia sutured and method of sewing conjoint tendon and fascia of internal oblique muscle to Poupart's ligament

Fig 155—Showing method of laying sutures above the cord

Fig 156—Showing method of imbricating aponeurosis under the cord

the peritoneum in any abdominal operation. Time consumed in this part of the operation is valuable time spent to protect the repair

4. *Fortifying the inguinal triangle.* Any relaxation of the tissue in Hesselbach's triangle is taken care of by suturing or imbricating the transversalis fascia from the pubic spine upward, well under the cord, being careful not to injure the deep epigastric vessels. This closes any defect at the internal ring and provides an extra layer of varying strength which serves to distribute the stress of intra-abdominal pressure evenly against the outer layers of the wall under construction. The repair is in principle a White fascia repair, similar to Andrews's<sup>3</sup> technic. The red muscle of the internal oblique is entirely disregarded and may be transplanted or excised for convenience. A suture is then

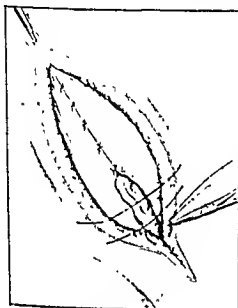


Fig. 157.

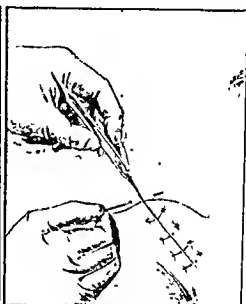


Fig. 158

Fig. 157.—Showing closure of Scarpa's fascia above the cord.

Fig. 158.—Closure of skin with interrupted end-on-end mattress sutures.

taken at the internal ring bringing the cord out at a right angle, the stitch being placed in the reflection of Poupart's ligament rather than the shelving edge to prevent tension. If the external oblique fascia has been split along the medial side of the external ring there will be enough outer leaf of fascia to allow placing of this suture. The next stitch is placed at the extreme lower end in the form of a figure 8, parallel or pulley stitch, the latter advocated by Col. Keller.<sup>4</sup> This stitch is placed in accordance with anatomical arrangement and in such a manner as to relieve tension on the remaining sutures. The first bite is on the medial side, then over the pubic spine, small bite on the medial side and sweeping bite taking in Gimbernats', Cooper's and Poupart's ligaments (Fig. 154). When this suture is tied the structures fall together, making the remaining ones more or less apposition sutures. If

this does not occur a similar second stitch can be placed above the first, or a curved incision can be made along the rectus sheath as advocated by Rienhoff.<sup>5</sup> A few sutures are placed above the cord (Fig 155) and the external oblique fascia closed. The outer leaf of this layer is imbricated or sutured to the medial leaf underneath the cord about halfway to the internal ring. It is then sutured over the cord. This raises the external ring, gives added support to the critical angle just above the pubic spine and still allows the cord to come out obliquely as it naturally does (Fig 156). The medial leaf of the external oblique should not be imbricated or sutured too far laterally under the cord or there will be too much strain on the tissue when the anesthesia subsides, the aponeurosis having a tendency to fly back in place like a bowstring.

5. *Closure of wound* Scarpa's fascia is closed over the cord taking small bites and using interrupted sutures (Fig 157). It is preferable to place the sutures so that the knot will be down in thin individuals (Fig 157). The skin is closed with interrupted end on end mattress sutures, the skin having been marled before making the incision (Fig 158). Careful closure of the skin and obtaining a neat scar does not add to the repair but certainly gives the patient confidence in his operation.

### ANALYSIS OF CASES

#### INDIRECT INGUINAL HERNIA

Chromic Catgut Used for Repair

320 Cases

304 Patients

#### Age of patient

18-20 years	33
20-30 years	103
30-40 years	73
40-50 years	58
50-60 years	28
60-70 years	8
70-80 years	1

Total

304 (16 patients had bilateral repairs)

#### Period of time under observation

6-12 months	71
12-18 months	71
18-24 months	35
24-30 months	53
36 months	2

Total

232 or 73 per cent  
(27 per cent were examined)

Pain

Twenty-one patients, or 9 per cent, complained of pain. Pain described as slight soreness, dull ache, or sharp shooting in character.

Enlarged testicle

One patient complained of enlarged testicle.

Recurrences

4 cases

Age 18-20, recurred right side in 1 year

Age 30-40, recurred right side in 1 year

Age 40-50, recurred left side in 1 year

Age 56, recurred right side in 1 year, had bilateral repair same day

There were 182 hernias on the right side, 138 on the left side. Operation was done in nine cases of bilateral hernia on the same day, with one recurrence on the right side. Seven patients with bilateral hernias were operated upon at separate times, with no recurrence. Recurrence rate 1.7 per cent.

INDIRECT INGUINAL HERNIA

Silk Used for Repair

106 Cases

100 Patients

Age of patient

18-20 years	8
20-30 years	18
30-40 years	22
40-50 years	35
50-60 years	13
60-70 years	3
70-80 years	1
Total	100 (6 patients had bilateral repair)

Period of time under observation

6-12 months	10
12-18 months	32
18-24 months	30
24-30 months	13
36 months	1
Total	86 (14 patients not observed)

Number of hernias observed 92

There were 55 hernias on the right 51 on the left

Pain

Ten patients complained of pain, described as stinging, drawing, pulling sensation

Atrophy of testicle 1

Infection 1



## Recurrences

Two cases

Five bilateral hernias, done on separate days, no recurrence

One bilateral hernia done on same day, no recurrence

Recurrence rate 2.18 per cent

Eighty-six per cent of the patients were followed 27 per cent were given follow up examinations

**Technical Notes**—In both series of cases the indirect hernias, with narrow neck sac at the internal ring and no weakness in Hesselbach's triangle, were repaired without transplantation of the cord, whether catgut or silk was used. There were very few cases of this type. Also, cases of undescended testicle were repaired without transplantation of the cord. Indirect hernias, with large mouth sac at the internal ring and weakness in Hesselbach's triangle, were repaired by a method similar to that used in repairing direct hernias with transplantation of the cord, regardless of type of suture material. The only difference is that in the catgut series autogenous fascia was used to reinforce the repair far more frequently than in the silk series. This may account for the higher recurrence rate in the silk series.

## DIRECT INGUINAL HERNIA

Chronic Catgut Used for Repair

375 Cases

308 Patients

## Age of patient

18-20 years	9
20-30 years	48
30-40 years	87
40-50 years	105
50-60 years	48
60-70 years	9
70-80 years	2

Total

308 (67 patients had bilateral repair)

## Period of time under observation

6-12 months	61
12-18 months	55
18-24 months	41
24-30 months	40
30-36 months	12
4 years	2
5 years	2

Total

213, or 69 per cent  
(52 per cent  
were examined)

Pain

Twelve patients, or 5.5 per cent, complained of pain

Mortality

One death from coronary thrombosis on the thirteenth day occurred in a patient aged 45 Mortality rate 0.26 per cent

There were 206 hernias on the right, 169 on the left side

Recurrences

6 cases

Age 20-30, trauma, 18 months

Age 50-60, within 3 months

Age 41, right side, 3 years

Age 34, left side, 20 months (McArthur technic)

Age 40, right side, 6 months (bad cough)

Age 44, left side, 2 years

There were 21 bilateral hernia repairs done the same day, 3 of the hernias recurred, 2 on the left side within 1 year, age 30-40, 1 on the left side in 18 months, age 49 Eighteen cases in this group were followed 9 cases were examined There were 46 bilateral hernia repairs done on separate days, with 1 recurrence, right side, age 38, 1 year Thirty two cases in this group were followed 13 cases were examined

Recurrence rate 3.8 per cent

Single direct hernia, 2.8 per cent

Bilateral repair same day, 16.6 per cent

Bilateral repair separate days, 3.1 per cent

One hundred of these hernias were bilocular or mixed type

DIRECT INGUINAL HERNIA

Site Used for Repair

325 Cases

293 Patients

Age of patient

18-20 years

2

20-30 years

48

30-40 years

69

40-50 years

123

50-60 years

40

60-70 years

11

Total

293

(32 patients had bilateral repair)

Period of time under observation

6-12 months

41

12-18 months

71

18-24 months

72

24-30 months

37

36 months

3

Total

224

(29 patients had bilateral repair)

**Pain**

Twenty four patients complained of pain on heavy lifting or numbness along lower part of scar

Atrophy of testicle 2

Infections 1 requiring removal of sutures

**Recurrences**

Two cases or 0.89 per cent

Seventy seven per cent of this group was followed and 39.3 per cent examined

There were 208 cases of bilocular or mixed type of hernia 26 bilateral hernias, separate repairs 3 bilateral hernias repaired the same day There were no recurrences after bilateral repair There were 184 hernias on the right side, 141 hernias on the left side

**Conclusions.—Suture Material**—In the catgut series of direct hernias autogenous fascia was used according to the McArthur<sup>6</sup> technic or by strips from the fascia lata when the structures for repair were not considered good One or the other method was also used in patients over 50 years of age, or when there were some possible predisposing factors for recurrence In the silk series, autogenous fascia was used only occasionally The two recurrences were in men over 50 years of age There were 51 cases in this age group all being followed but 5 Even though many in this age group may present good structure for repair, it is our opinion that the use of autogenous fascia to reinforce the repair insures a better result regardless of the type of suture material used The last few years we have used prepared fascia satisfactorily in selected cases In comparing the results in direct hernia silk would appear to be the superior suture material

**Indications for Operation**—The literature since 1930 shows the recurrence rate in direct hernias to be quite high Some authors<sup>7</sup> feel that direct hernia is entirely different from indirect that it rarely becomes strangulated and that it should not be operated upon unless it causes discomfort, or the sac has a diverticulum Many times direct hernia is a harmless condition, and it is our opinion that occasionally patients are operated on when they should not be The patients of whom we speak are the ones who have an enlarged external ring with only weakness in Hesselbach's triangle, and in the true sense of the word do not have an inguinal hernia These patients are operated on because it is necessary to correct the condition before employment can be obtained Most of them do not have any complaints and are able to work, but when the diagnosis of hernia is made correction is necessary or they will not be able to obtain positions and if they are compensation cases, they may be totally disabled Operation is necessary to keep from throwing many compensable cases upon the various communities

**Bilateral Hernia Repair**—Bilateral hernia repair is not advocated because the recurrence rate is higher, the postoperative complications are

greater, and the postoperative convalescence is not so smooth. This is confirmed by numerous authors. The statement is often made that a bilateral repair can be done on a patient because he has small hernias or certain types of hernias. This does not hold true, because the factors mentioned above are still present, regardless of the type of hernia. The only possible exception would be straight, indirect, congenital hernias in young individuals. The other factors to be considered are prolonged hospitalization, prolonged disability, and added risk of second operation. Separate repair does not necessarily entail more than seven to ten days of additional hospitalization or more than two weeks longer disability. A little more time spent at the first sitting may prove to be economical later on in life. In doing the operation in two stages there is actually less risk of complications. When one side is repaired a known smaller risk is accepted and if complications develop it indicates what may be anticipated in repair of the other side. Increased precautions can be taken because, being forewarned, we should be forearmed.

There were 121 bilateral hernias in this group, 34 had their repair done on the same day and we were able to follow 21 of the patients. There were 4 recurrences, a rate of 13 per cent, 87 had their repair done on separate days and we were able to follow 70. There was one recurrence, a rate of 1.4 per cent.

#### SUMMARY

A follow up study of 1126 cases of inguinal hernia has been presented with description of our technic.

A discussion of the etiology of hernia and of the anatomy of the inguinal region has been purposely avoided. A good description of the latter has recently been given by Anson and McVay<sup>3</sup> and Rienhoff. In this study, silk is apparently the suture material of choice, except in the indirect group which does not run exactly to form. The use of autogenous fascia also augments the repair. High ligation of the sac with careful dissection will decrease the recurrence rate and possibly help clear up the question of whether recurrences are true recurrences or sacs left in place. While we prefer to use fine silk in hernia repairs and fascia in selected cases, we feel that the suture material is only secondary. In this day and age, having so many manifestations of the various operations, it is our opinion that the result obtained will depend entirely upon the meticulous care given to all details at operation. A surgeon doing hernia operations should have enough experience to vary his technic as indicated.

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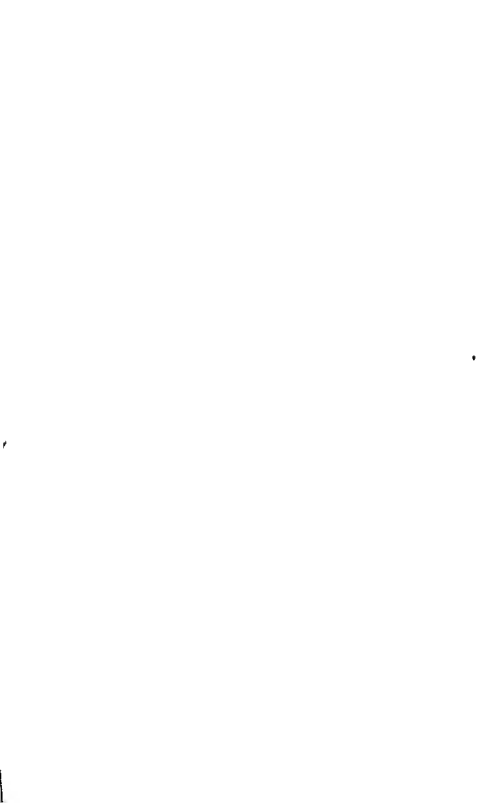
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# THE SURGICAL CLINICS of NORTH AMERICA

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## SYMPOSIUM ON COMMON PROBLEMS IN GENERAL SURGERY

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### FOREWORD

This symposium was designed primarily to present important surgical principles which have developed during the past few years. As in most symposia it became necessary to vary the original subject matter with other papers in order to make it interesting for the general reader.

The editor does not subscribe to all of the opinions brought out by the contributors but feels that the authors are all surgeons of well tried ability and therefore the reader may select what he chooses from their presentations.

FREDERIC W. BANCROFT,  
*Consulting Editor*



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## PULMONARY ABSCESS, ACUTE AND CHRONIC

CHARLES W. LESTER, M.D., F.A.C.S.\*

ABSCESS of the lung is a purulent infection of the lung parenchyma and is to be distinguished from bronchiectasis an infection of the bronchi and empyema thoracis, an infection of the pleural space. There is a certain amount of confusion about lung abscess because some reports cover a large series extending over a long period without regard to type, etiology or treatment, as that of D'Angianni<sup>1</sup> while others limit the subject to a certain type encountered during a period when treatment was more or less standardized, as that of Sweet. Furthermore a large municipal hospital which includes among its patients many chronic alcoholics will have a different type of abscess than a hospital which serves a residential district where the people habitually use toothbrushes.

### ETIOLOGY

*Aspiration* is thought to be the cause of most lung abscesses especially the many that are preceded by surgical operations, as well as those that follow unconsciousness from other causes such as head injuries, alcoholism, epilepsy, immersion and the like. *Pneumonia* is listed by many as a potent cause of lung abscess but the abscess follows so soon after the onset of symptoms that aspiration pneumonia rather than the typical lobar or bronchial pneumonia must be the cause. Antecedent unconsciousness is not necessary as most of these patients have a weak or absent gag reflex in addition to a septic mouth and aspiration could occur during sleep.

Certain lung abscesses are of an *embolic* origin. Among these are the ones following an operation under regional anesthesia or associated with septic operations as well as those preceded by pulmonary infarct without operation.

*Bronchial obstruction* can also produce lung abscess. The obstruction may be due to bronchial stenosis or to an inhaled foreign body. Bronchogenic carcinoma or other lung tumor is frequently associated

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with pulmonary suppuration and should always be suspected in obscure cases

Bullets and other *foreign bodies* entering the lung through the chest wall are said to cause lung abscess but the statistics from our own battle fronts as reported by Churchill,<sup>3</sup> by Carter and DeBailey<sup>4</sup> and by Blades and Dugan<sup>5</sup> indicate that such etiology is infrequent. Probably the chief factor in this is the early removal by experienced thoracic surgeons of foreign bodies larger than 1.5 cm. lodged in the lung although the sulfonamides and penicillin must receive some of the credit

### BACTERIOLOGY

Most lung abscesses are foul, indicating the presence of anaerobes. Anaerobic streptococci, spirochetes and fusiform bacilli such as are found in the mouth are common. Pyogenic organisms are nearly always associated but when they occur without the anaerobes the abscess is not foul. In the unusual cases of lung abscess associated with typical pneumonia the organism of the pneumonia is responsible and Friedlander's bacillus is the worst offender.

### PATHOLOGY

The fundamental pathology of lung abscess is the same as that of abscess anywhere else. Such differences as do exist arise from anatomical conditions peculiar to the lung. Exudation and cellular infiltration fill the alveoli producing pneumonia and consolidation. Necrosis and liquefaction occur but, since bronchi communicate with the abscess, pus can drain off and be replaced by air producing an abscess within the tissues where air overlies the pus. Sometimes a large area of lung becomes gangrenous and separates to lie as a sphacelus in the cavity. Fibrosis likewise occurs but its stiffening effect is greater than elsewhere because of the delicate nature of the surrounding tissue. Most abscesses are single, lie near the periphery and are separated from the visceral pleura by compressed and avascular lung tissue. However, multiple lung abscesses are not uncommon especially if of an embolic origin, and may be in one or both lungs.

If liquefaction occurs rapidly the thin shell of peripheral lung tissue may rupture and flood the pleural cavity, or perforation may take place slowly enough to permit the formation of enough adhesions to wall off the empyema. Usually, however, the visceral and parietal pleura adhere firmly together without the production of empyema.

## DIAGNOSIS

The diagnosis of lung abscess should always be suspected when there is a *history* of unconsciousness from any cause followed in a few days by cough, fever and sputum, especially if the sputum is foul. It should also be suspected with a history suggestive of infarction or with the development of foul sputum associated with atypical pneumonia.

The *physical signs* are those of consolidation at first unless the abscess is secondary to bronchial obstruction. In that case the signs are those of atelectasis. Later when the abscess breaks down and communi-



Fig. 159.—Multiple abscesses of the lungs. The abscess in the upper part of the left lung is draining spontaneously and clearing up. That on the right side appears as an area of consolidation.

cates with a bronchus amphoric breathing and consonating rales may be heard. The patient is febrile and raises a large amount of sputum, usually foul. The sputum may amount to 500 cc. a day and layers on standing, forming an upper frothy layer, a middle fluid layer and a bottom layer of pus and elastic tissue. Blood may be present.

X-ray is essential in making a diagnosis and indispensable in locating the abscess (Figs. 159–162). The abscess produces a solid shadow at first until liquefaction has occurred and a bronchial connection established permitting air to enter the cavity. Then a fluid level appears which shifts with the position of the patient. When the abscess is empty x-ray shows only an empty cavity.



Fig 160 Overexposed film shows shadow in the right lung to be composed of several abscesses



Fig 161—Lateral view of the same shadow in the right lung



Fig 162—The abscess in the right lung has been drained by resecting the fourth and fifth ribs. The site of operation was determined by study of the postero-anterior and lateral films of Figs 160 and 161.

*Bronchoscopy* is a valuable adjunct in the diagnosis and, by noting the bronchus from which the pus is coming, will locate the involved lobe. Should the abscess be due to obstruction the bronchoscopic examination may disclose the presence of carcinoma or other obstructing agent.

#### TREATMENT

At the start of any discussion as to the treatment of lung abscess it is well to remember that bronchi provide natural drainage tracts which may be adequate to drain the abscess and permit healing. Hence a certain number of lung abscesses will heal spontaneously, especially if aided by postural drainage. This number is variously estimated as 20 to 30 per cent.

**Nonsurgical Treatment**—Nonsurgical treatment can be divided into the physical methods and the use of drugs. The physical methods consist in bronchoscopic and postural drainage. *Bronchoscopic drainage* can be done once or twice a week and its value lies chiefly in the removal of thick secretions which tend to plug the bronchi and retard drainage. If the secretions are fluid and are coughed up readily not much can be expected from this method.

*Postural drainage* should always be tried. It is accomplished by putting the patient in a position which allows gravity drainage of the abscess. The standard position is with the patient's legs on the bed and the rest of his body hanging straight down and supported by his hands on the floor. If, however, the abscess is in an upper lobe above the main bronchus this position will prevent drainage rather than aid it and in this instance the position should be chosen which x-ray shows will be the most suitable. The posture is maintained for ten or fifteen minutes during which time the patient coughs and expectorates into a basin on the floor between his hands. The position is tiring and requires a considerable amount of stamina. In the acute stage when the patient is too sick to maintain any such position postural drainage may be accomplished by raising the foot of the bed and having the patient lie in the optimum position for obtaining drainage.

*Drug treatment* of lung abscess is notoriously unsatisfactory. Guanicol has its advocates as does salvarsan when spirochetes are found in the abscess but they appear to be without virtue. More can be expected from the use of the sulfonamides and certainly improvement seems to have followed their use but the number of actual cures is very small.

The value of penicillin is not yet established as, due to the restricted supply, it has not been available for the treatment of enough cases.

Nevertheless, the results so far have been encouraging. It has been given intramuscularly or by continuous intravenous infusion to the extent of 200,000 units a day. It has also been sprayed directly into the lungs by a nebulizer where it probably acts by absorption and is without local effect. When the supply becomes adequate it may well prove to be very important in treating lung abscess.

A valuable adjunct in the treatment of foul lung abscess is the use of 100 per cent *oxygen inhalations* through a B.L.B. mask or similar appliance. Anaerobes are responsible for the fetor and likewise for many of the complications of lung abscess. In the majority of cases they can be controlled by constant inhalations of oxygen, the mask being kept on at all times except during meals. An oxygen tent or nasal catheter is inadequate for the treatment as they are not capable of securing 100 per cent oxygen concentration. When properly employed oxygen will clear up the odor but it rarely produces a cure.

**Surgical Treatment**—The nonoperative methods of dealing with lung abscess should always be employed first, but in the majority of cases they are entirely inadequate and some form of operative intervention becomes imperative. The question naturally arises as to how long nonoperative methods should be used before resorting to operation. In general it can be said that as long as improvement is shown operation can be deferred unless the improvement is so slow that chronicity threatens. A definite time limit cannot be set. One case may need operation after a few days or even as a primary treatment while another may show enough progress to justify continuing treatment for several weeks. If, at the end of three months the abscess is not healed or on the point of healing, surgical drainage is indicated. Longer delay may lead to an abscess wall so stiff that drainage is useless and lobectomy becomes necessary.

Operative treatment consists in either drainage of the abscess or removal of the lobe or lung involved. The former is usually successful in the early cases. Resection of the lung is employed when it is obvious that the abscess wall is too stiff to collapse or when the abscess has been drained and fails to heal after several months.

**Drainage of the Abscess**—The first requisite for drainage is accurate localization of the abscess. For this, good postero anterior and lateral x-ray films are necessary. The postero anterior view (Fig 160) will locate the distance from the vertebral spine and the rib which crosses the cavity. The lateral film (Fig 161) will show how far it lies from the anterior or posterior chest wall. The rib should be counted, the



Fig. 163.—Postero-anterior film of lung abscess in left lower lobe. The patient is lying on the right side and the fluid level is parallel to the table.



Fig. 164.—Lateral view with patient lying on the back. The fluid level is in a different position but still parallel with the table. This lung abscess followed tonsillectomy and was of two years' duration. It originated in the left lower lobe but in the two years of its duration involved the left upper lobe necessitating pneumonectomy.



distances measured and the spot marked on the chest wall over the abscess. There is nothing so inaccurate as an attempt to estimate the site. Oblique views or tomography may also yield valuable information.

Rabin<sup>6</sup> has devised a method of locating the abscess which consists in locating the site by films or fluoroscope and injecting 0.2 cc each of lipiodol and methylene blue between the intercostal muscles directly over the rib to be resected. The patient is again placed under the fluoroscope and the relative positions of lipiodol and abscess noted. After the incision is made the methylene blue will locate the lipiodol and hence the abscess. Unless great care is used in injecting the methylene blue it will be found at operation to have spread over a large area and result in confusion instead of help.

The operation is done under local anesthesia if possible. The patient lies with the operative site uppermost unless the abscess is very wet. In that case he is in a sitting position leaning across a table adjusted to his height.

An incision is made, the underlying muscles divided and the rib carefully identified. With the edges of the incision retracted, two or three ribs may be exposed, hence it is imperative to locate the rib again by counting. Having definitely determined the rib 4 or 5 cm. of it is removed by subperiosteal resection and the parietal pleura exposed through the rib bed without opening it. Movement of the lung is then noted, and if a moving lung is encountered the wound is packed with iodoform gauze and the skin closed over it. Any attempt to incise a lung abscess through a free pleura is almost sure to result in a large putrid empyema. After ten days the wound is reopened and the packing removed. The pleura should be adherent. The operation is then continued as it would be had a fixed pleura been encountered at the time of rib resection.

With the adherent lung exposed through the rib bed a 17 or 18 gauge needle attached to a syringe is inserted in the direction of the abscess. A little tension is kept on the plunger so that pus will be aspirated as soon as found and so that no air will enter any pulmonary vessel that may be traversed. This exploratory aspiration is continued until the abscess is found, remembering that air is encountered in a lung abscess as often as pus. Then a scalpel or pointed clamp is inserted into the abscess along the needle and the abscess is opened just enough to receive the suction tip which is immediately thrust into the cavity. Before going farther the contents of the cavity are sucked out, great care being taken to prevent the entrance of air. If an airway is es-

tablished before the cavity is empty the contents may be sucked into the rest of the lung during inspiration and the patient drowned in his own pus

When the abscess has been emptied the cavity is unroofed, all septa broken down with the finger and iodoform gauze packing loosely inserted. The chest wall wound is kept open by covering the edges with petrolatum gauze. The packing is left in for a day and then gradually removed during the next two or three days and replaced by a rubber tube of ample diameter. As the abscess heals the diameter of the tube is decreased but not the length. When the cavity has been reduced to the size of a Dakin's tube, as shown by x-ray after the instillation of lipiodol, the tube is removed and the tract allowed to heal. No attempts at removal of the tube or closure of the sinus should be made when there is much drainage. The surface wound may heal readily but the abscess remain active and require reopening.

All lung abscesses have a bronchial communication at one time or another and a failure of the bronchial fistula to close is a potent factor in delayed healing. Closure of the fistula may be accomplished by free fat transplants as advocated by Neuhof<sup>8</sup> or by muscle flap implant as described by Crafoord and Linton<sup>9</sup> and by Pool and Gatlock.<sup>10</sup> In my experience the *muscle flap implant* has been much more effective. A piece of muscle large enough to fill the sinus is mobilized leaving attached that part nearest the sinus. Any available muscle can be used for this. The free end is then sutured into the bottom of the sinus which has been denuded of its epithelial covering and the wound loosely closed.

If the abscess cavity remains too large it may be reduced in size by *thoracoplasty* before attempting to close it but the drainage should be reduced to a minimum before resorting to this procedure. This is the only occasion in which thoracoplasty is justifiable in the treatment of lung abscess.

*Lobectomy or Pneumonectomy*—When it is obvious that a cavity cannot be closed by any of these measures, or when, because of chronicity or because of the multiplicity of small abscesses it is obvious that drainage will fail, lobectomy or pneumonectomy is indicated. Under these circumstances the pulmonary section must be done with a tourniquet, since the inflammatory adhesions are too dense to allow individual ligation of the vessels and bronchus. Furthermore, the pleural adhesions are always dense and mobilization of the lung is sure to be a tedious and sanguinary procedure. Because of interlobar ad

hesions, good lung may have to be sacrificed with the bad but in this case it is frequently possible to leave enough of the uninvolved lobe to cover the bronchial stump. Occasionally the stump is so well covered that subsequent empyema is reduced to a minimum and drainage of the pleural space will not be required for long. Usually, however, and certainly when initial drainage of the lung abscess has been performed, lobectomy or pneumonectomy is followed by considerable infection of the pleural space requiring long drainage.

Should the adhesions be so dense and vascular that mobilization is impossible, cautery lobectomy may be done. Regional anesthesia or anesthesia with a nonexplosive agent must be used. Regional anesthesia is possible because the lung itself is almost insensitive. The lung in the vicinity of the abscess is widely exposed and the adjacent chest wall protected with moist pads. A regular tinsmith's soldering iron is heated to a cherry red and applied to the lung in such a way that the tissue is coagulated but not burned away. As much as possible is treated this way and then the coagulated area is allowed to slough. Separation is complete in about two weeks and then the procedure may be repeated as often as is necessary to effect the desired removal. The danger of hemorrhage is minimized by coagulating the tissue without burning into any vessels with too much heat. The large vessels near the hilum must be studiously avoided, however, but even so packing may be required to control bleeding when the slough starts to separate.

#### COMPLICATIONS

*Bronchial fistulas* are so much a part of the operative treatment of lung abscess that they are hardly to be rated as complications. When they persist they are bothersome and present a problem. Their treatment has already been discussed as they occur after drainage of the abscess. After pulmonary section the treatment is essentially similar and Schede thoracoplasty is often necessary in addition. It is well to remember that a persistent bronchial fistula can be dressed by the patient and need not be harmful or disabling. In certain instances they are perhaps less dangerous than some of the radical methods used for their closure.

The other complications are almost always the result of infection and *empyema* is the most common. This may be a massive empyema due to the perforation of the abscess into the free pleura but is usually well localized by adhesions before the abscess perforates. The massive empyema is apt to be rapidly fatal but the localized empyema seems

to be merely a continuation of the original process. The treatment is adequate drainage by rib resection at the most suitable dependent point. Intercostal drainage is inadequate.

*Cellulitis of the chest wall* is due to the needling of a foul empyema. The anaerobes gain access to the cellular tissues of the chest wall along the needle track and produce a fulminating infection which may be rapidly fatal. Immediate wide incision is necessary at the site of the needle puncture and the empyema should be drained at the same place regardless of whether it is the most suitable spot. This is about the only time empyema calls for an emergency operation. Obviously cellulitis of the chest wall is easier to prevent than to cure. An anaerobic infection should be suspected when the sputum is copious and foul. Needling of the pleural space should be done only in the operating room in these circumstances and the empyema immediately drained if putrid pus is encountered. If foul pus is encountered when aspiration is done under other circumstances, surgical drainage should be done at the earliest possible moment.

Profound *sepsis* may develop from a lung abscess. Early and adequate drainage is indicated but, unfortunately, the abscesses are apt to be multiple and the patient in a critical condition when this complication arises. As many as possible should be drained as herein lies the only hope. More adequate drainage can be done later if the patient improves.

*Tuberculosis* in the abscess cavity is more frequent than usually considered, as noted by Baum and Amberson<sup>10</sup>. This is rarely a pyogenic infection in a pre-existing tuberculous cavity but rather an activation of a quiescent tuberculous lesion by the acute suppuration. Drainage of the abscess is indicated, but on the subsidence of the acute infection it should be treated as a cavernostomy and closed by thoracoplasty at the proper time.

*Brain abscess* is the most heart-breaking complication of lung abscess and it is not uncommon. Septic material enters a pulmonary vein and is carried to the end arteries of the brain. The abscesses can occur at any time in the course of the disease, are usually multiple, and invariably fatal. Rarely a solitary abscess will respond to surgical drainage and sulfonamides and penicillin should be used but the prognosis is extremely grave.

#### SUMMARY

1 Abscess of the lung is usually the result of aspiration but may be due to a blood borne infection or bronchial obstruction.

2 Lung abscess is usually foul indicating the presence of anaerobes but may be caused by pyogenes alone and not foul

3 Diagnosis is made by the x-ray demonstration of a cavity with a fluid level

4 Bronchoscopic or postural drainage aided by various drugs can be attempted but surgical drainage is required in most cases and should be done early

5 Chronic lung abscesses, drained or undrained, should be treated by lobectomy

6 The complications are due to the infection

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## SURGERY OF PULMONARY TUBERCULOSIS

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It is believed that mankind suffered from pulmonary tuberculosis as far back as civilization can be traced. Reference to the disease in medical literature can be found in the earliest records. However, no direct attack on the disease was suggested or undertaken before the nineteenth century. Then, in 1821, Carson suggested pneumothorax in the treatment of pulmonary tuberculosis. He said, "It has long been my opinion that if ever this disease is to be cured, and it is an event of which I am by no means disposed to despair, it must be accomplished by mechanical means, or in other words, by a surgical operation." About sixty years later Traussant (1880) and Forlanini (1882) advised the use of collapse therapy on the basis of clinical and pathological studies. Forlanini observed that, following spontaneous pneumothorax, "the lung shrivels—the lung no longer breathes—the lung that cannot breathe any more cannot any more cough or expectorate." In 1894 Forlanini reported on his results of induced pneumothorax. Although his results were not encouraging they did lead the way to the modern concept in the management of pulmonary tuberculosis.

In the interval between the two reports issued by Forlanini, de Cereville (1885) apparently recognized that pneumothorax could not be induced in every case and that in such instances relaxation of the lung could be obtained by the removal of the overlying ribs. This proved incomplete and the results were unsatisfactory. Bauer recognized the shortcomings of this operative procedure and on December 11, 1907 performed an extensive thoracoplasty removing larger segments of the second to the ninth ribs with an uneventful result. About the same time Friedrich recognized that leaving the first rib in place permitted the lung to become suspended from above and that the collapse could be enhanced by the removal of that rib. Accordingly, he suggested that the first rib too be removed. In 1911 Wilms showed

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that if the ribs were resected subperiosteally in the paravertebral region the degree of collapse of the lung was greater and that the complications encountered by his predecessors were less apt to occur. Accordingly, on January 24, 1911 he performed an extrapleural paravertebral thoracoplasty resecting parts of the upper eight ribs (Sauerbruch in 1909 performed the same operation, antedating that of Wilms. However, he felt that the results were not satisfactory and did not perform the operation again for some time.) By dint of perseverance, trial and modification, the modern thoracoplasty was evolved. Today this procedure forms the keystone of the surgery of pulmonary tuberculosis.

No phthisiologist today would consider his care of the tuberculous patient as adequate without the services of the thoracic surgeon in whose armamentarium are available such procedures as are outlined below. Granting that some other procedures may be added and that some of those mentioned are not as serviceable as others, on the tuberculosis services at Kings County, Kingston Avenue and Sea View Hospitals, I have found these procedures of value in accordance with the limits mentioned.

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|--|---|
| <p>I Pneumothorax</p> <p style="padding-left: 20px;">A Closed</p> <p style="padding-left: 20px;">B Open</p> <p>II Pneumonolysis</p> <p style="padding-left: 20px;">A Closed</p> <p style="padding-left: 20px;">B Open</p> <p>III Nerve Surgery</p> <p style="padding-left: 20px;">A Phrenic</p> <p style="padding-left: 40px;">1 Crush</p> <p style="padding-left: 40px;">2 Section</p> <p style="padding-left: 40px;">3 Evulsion</p> <p style="padding-left: 20px;">B Intercostal</p> <p style="padding-left: 40px;">1 Local anesthetic block</p> <p style="padding-left: 40px;">2 Alcohol block</p> <p style="padding-left: 40px;">3 Section</p> | <p>IV Cavitary Surgery</p> <p style="padding-left: 20px;">A Monaldi</p> <p style="padding-left: 20px;">B Cavernostomy</p> <p>V Thoracoplasty</p> <p style="padding-left: 20px;">A Paravertebral</p> <p style="padding-left: 20px;">B Anterior</p> <p style="padding-left: 20px;">C Revision and/or Scapulectomy</p> <p>VI Excision</p> <p style="padding-left: 20px;">A Lobectomy</p> <p style="padding-left: 20px;">B Pneumonectomy</p> <p>VII Surgery for Empyema</p> |
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#### SELECTION OF CASES

Collapse therapy should be instituted only (1) in those cases in which the sputum or gastric washings are positive for tubercle bacilli and (2) in those cases in which there is a caseous pneumonic (ulcerative) tuberculosis. The other forms of pulmonary tuberculosis—exudative, exudative productive and productive—are nonsurgical.

## PNEUMOTHORAX

**Closed Pneumothorax**—Closed pneumothorax consists of the introduction of air into the pleural cavity by means of a needle introduced between the ribs. Since the greatest respiratory movement of the chest takes place in its lower third and since most tuberculous cavities are situated in the upper third of the lung, it is preferable to insert the needle in the posterior axillary part of the lower thorax. If pleural entry cannot be made at this site, others in the surrounding regions should be tried before the procedure is considered impossible. The introduction of air into the pleural cavity should be frequent enough to slowly collapse the lung—perhaps every other day for a week or ten days. Thereafter the refills may be less frequent.

By suppressing the normal negative intrapleural pressure, the elastic lung will collapse against the hilus. If the pressure within the pleural cavity is maintained at atmospheric pressure then the lung will remain in the collapsed state. When however, the lung is attached to the chest wall the mediastinum being fixed, pressures above atmospheric may be necessary to collapse the lung, coaptate the walls of the cavity and convert the sputum. In these latter cases *complications* such as effusion, spontaneous pneumothorax, pleurobronchial fistulas and empyema may occur readily. Thus those cases requiring the least possible increase in pressure will more efficiently collapse the cavity. In patients having bilateral cavitation it is advisable to induce the pneumothorax on the side with the more advanced lesion first and then to watch the progress of the contralateral side. As long as repeated x ray studies indicate spontaneous regression the patient should be spared the contralateral pneumothorax (Figs 165, 166). Bilateral pneumothorax unless selective often indicates minimal or inadequate collapse on both lesions.

**Open or Extrapleural Pneumothorax**—The indications for extrapleural pneumothorax are essentially the same as those for intrapleural pneumothorax and the failure to produce adequate collapse by the latter procedure. Preoperatively by means of x ray studies the diseased area is located and the limits to which the lung should be collapsed are defined. A rib overlying this area is then resected subperiosteally for a distance of about 4 inches. The intercostal muscle above this region and its adherent endothoracic fascia are separated from the underlying outer surface of the parietal pleura. By means of judicious blunt and sharp dissection the lung and its adherent parietal pleura are stripped free from the chest wall until the desired collapse is obtained. In view



of the fact that the cases submitted to this procedure have many adhesions bleeding from the chest wall is frequently encountered. Before the wound is closed it is imperative that all bleeding be controlled. The wound is then closed tightly so as to prevent the loss of air from the extrapleural pocket into the surrounding tissues.

Postoperatively the space should be refilled with air immediately after the wound is closed, developing a pressure equivalent to about 5 cm of water. Thereafter the refills should be given daily for about ten days, leaving the final pressure in the space at a level above 5 cm of water. Subsequent refills are given as in an intrapleural pneumo-



Fig 165

Fig 166

Fig 165—Bilateral caseous pneumonic tuberculosis (Same case as Fig 166)

Fig 166—Bilateral induced pneumothorax (Same case as Fig 165)

thorax. Experience has shown that unless the pressures are maintained considerably above atmospheric pressure some of the space may be lost.

The complications of this procedure are (1) dyspnea due to the relatively rapid collapse of a considerable portion of the lung tissue and the highly positive extrapleural pressure effects on the surrounding lung tissue, vessels and heart, (2) subcutaneous and mediastinal emphysema due to the increased pressure in the extrapleural space and leakage of air through the line of suture, (3) hematoma due to bleeding into the extrapleural pocket as a result of an oozing from the chest wall, (4) loss of the effectual collapse due to partial expansion of the lung because of inadequate refills, (5) effusion as a result of the highly

positive pressures necessary to maintain the collapse of the lung, and (6) extrapleural empyema as a result of organisms reaching the extrapleural space from the ruptured lymphatics of the chest wall, the traumatized lung tissue or from without. In view of these possibilities this procedure has not found favor with many thoracic surgeons.

### PNEUMONOLYSIS

**Closed or Jacobaeus Pneumonolysis**—Whenever an intrapleural pneumothorax is induced and the resulting pulmonary collapse is inadequate because of adhesions between the lung and chest wall, section of the adhesions will permit more efficient collapse of the lung by means of pneumothorax. In the closed pneumonolysis or Jacobaeus operation the adhesions are sectioned under direct visualization (with the thoracoscope) by means of the galvanocautery or high frequency cautery and coagulation electrodes. There are available several instruments for this procedure, the chief difference depending upon whether a single or double puncture is required and the advantages accruing from such procedure. The writer prefers the double puncture method, using the thoracoscope through one puncture site and the cautery through the other, because this permits interchange of position of the instruments and allows for a greater range of exploration and operation.

Before the punctures are made the adhesions should be localized as far as possible, on roentgenograms or preferably by fluoroscopic studies, so that the puncture is not so directed as to traverse intrapleural adhesions or injure the underlying lung tissue. A complete thoracoscopic examination of the pleural cavity and the nature of the adhesions should be made before the surgeon embarks on the operation proper. The adhesions should be studied individually as to length, width, thickness and position. They should be transilluminated and studied for the presence of lung tissue and vessels. Adhesions which are very short and thick and/or lie close to vital structures not allowing sufficient room in which to safely manipulate the instruments or which contain lung tissue in close approximation to their insertion in the chest wall and which cannot safely be sectioned without the possibilities of injuring the lung should not be cut. Any adhesion which contains a vessel which in the operator's opinion cannot be coagulated with complete security should not be tampered with. Having studied the nature of the adhesions and determined which are sectionable, the question then arises—if the adhesions which may be safely sectioned were cut, would the resulting pulmonary collapse be adequate to con-

of the disease. If not, then the adhesions should not be sectioned. If there is more than a reasonable doubt that the adhesions may be safely cut then it is better to err on the side of conservatism than on the side of boldness.

If the decision to cut the adhesions is made, the most advantageous site for the second puncture is located by means of a careful thoracoscopic examination. The cautery is inserted through the second puncture site and the adhesions are cut close to the chest wall and under constant visualization. All bleeding must be thoroughly controlled before passing from one adhesion to another. Short adhesions may be



Fig 167



Fig 168

Fig 167—Right induced pneumothorax with incomplete collapse of the lung because of some apicolateral adhesions (Same case as Fig 168)

Fig 168—Complete collapse of the right lung after section of the suspending adhesions (Same case as Fig 167)

etched by the introduction of more air into the pleural cavity so as to collapse the lung additionally, thereby permitting safer section of the adhesion (Figs 167, 168). Care must be exercised not to induce too high an intrapleural pressure, for after the adhesion is cut the lung may herniate through the cut end of the adhesion. The skin wounds are closed with figure of 8 sutures. Other methods of closure have been devised so as to prevent subcutaneous emphysema, none however prevent the vent in the parietal pleura from which site the air leaks into the subcutaneous tissues.

Immediately after the wounds are closed the intrapleural pressure

should be determined and adjusted to a slight subatmospheric level. In such cases the subcutaneous emphysema will be minimal. Pneumothorax refills should be given every other day for about a week or ten days with the final pressure maintained below atmospheric pressure. Adhesions are nonsectionable in 20 to 30 per cent of the cases and the remaining cases are about equally divided between those in which all the adhesions may be sectioned to produce a satisfactory collapse of the lung and those in which the adhesions cannot be completely sectioned or the result is not completely satisfactory.

The complications following intrapleural pneumonolysis are as follows:

- 1 Subcutaneous Emphysema—Transient collections of the air in the local subcutaneous tissues are seen in almost every case. However, increasing and more extensive emphysema is encountered as a result of increased intrapleural pressure, to perforations of the lung which close spontaneously after several days and finally to the development of a pleurobronchial fistula which permits air to enter the pleural cavity but not leave that space by the same route. As the air increases in the pleural cavity, the pressure increases and forces the air into the subcutaneous tissues.

- 2 Serous Effusion—Some serous effusion develops in about 75 per cent of the cases of closed pneumonolysis. It is often due to the mechanical trauma to the parietal pleura and lung and to the irritation of the pleura by the blood which has trickled into the pleural cavity. In about 30 per cent of the cases the fluid is absorbed in a short time and in about an equal number of cases it may remain or increase in volume.

- 3 Hemorrhagic Effusion—Bleeding into the pleural cavity may occur as a result of an ooze from the chest wall or from the traumatized lung. More active bleeding may occur as a result of injury to the intercostal vessels. More commonly, however, it is the result of inadequate thermocoagulation of the vessels in the adhesion or the severance of a larger vessel or injury to the lung tissue. Massive hemorrhage into the pleural cavity, although it does occur, is not very common.

- 4 Spontaneous Pneumothorax and Pleurobronchial Fistula—This complication is generally the result of thermocoagulation of the lung tissue. It may also occur in those cases in which some of the adhesions are left in place or in which the adhesions are incompletely divided, so that increased intrapleural pressure due to the pneumothorax places

additional strain upon the adhesions, causing them to rupture. Spontaneous pneumothorax and/or pleurobronchial fistulae occur in about 0.5 to 1 per cent of the cases. This complication occurs in direct proportion to the risks taken by the surgeon.

5. Empyema.—A collection of pus in the pleural cavity occurs in about 8 per cent of the cases in which the adhesions are sectioned. In about 1 per cent of the cases the empyema is nontuberculous, in about 4 per cent it is tuberculous and in the remaining cases it is mixed tuberculous. The nontuberculous empyema is generally due to introduction of organisms at the time of surgical intervention. However, it may also be due to injuries to the lung as are the tuberculous and the mixed tuberculous empyemas. The incidence of empyema is dependent also upon risks taken by the surgeon.

The question often arises whether the adhesions should be sectioned in the presence of a considerable amount of fluid in the pleural cavity. There is no contraindication in those cases in which the fluid is clear and abacterial. However, if the fluid is turbid and contains organisms the pneumonolysis should not be performed or at best most cautiously.

Open Pneumonolysis.—Exploratory thoracotomy to expose, ligate and section adhesions in the pleural cavity is an unwarranted procedure in the light of the possible complication. If the adhesions cannot be safely sectioned by means of a closed pneumonolysis, some other surgical procedure should be considered. This operation has not received much enthusiasm among surgeons.

#### NERVE SURGERY

Phrenic Nerve Surgery.—The diaphragm is innervated chiefly by the phrenic nerve of the corresponding side. It is believed that immobilization of the hemidiaphragm by interruption of the nervous impulses reaching it through the phrenic nerve will have a beneficial effect upon a tuberculous cavity. The phrenic nerve may be crushed (*phrenemphraxis*), or it may be divided or sectioned (*phrenicotomy*), or it may be evulsed (*phrenicoexeresis*).

The proper position of the patient on the operating table facilitates exposure of the phrenic nerve. The patient should be placed in the supine position,\* with the head rotated to the contralateral side. Under local infiltration anesthesia a transverse incision is made about  $\frac{1}{2}$  inch above the clavicle, parallel to it and about  $1\frac{1}{2}$  inches in length, be-

\* A small sandbag placed between the shoulder blades will help extend the muscles of the neck and aid in the exposure.

ginning at the lateral border of the sternomastoid and extending outwards. The phrenic nerve is exposed as it crosses in front of the scalenus anticus and behind the deep layer of the deep cervical fascia, from the lateral border of the scalenus anticus to the medial border along which it descends into the thorax. The nerve is freed from the surrounding tissue and placed between the blades of a crushing clamp. The patient is then instructed to take a deep breath toward the end of which the nerve is clamped. A spastic convulsive contracture of the hemidiaphragm will be noted. The nerve may then be clamped, cut, partially excised or evulsed. In about half of the cases the nerve will be anomalous in that it crosses at a higher level or that all the tributaries have not joined into one trunk before crossing the scalenus anticus. In other instances the nerve may enter the thorax either as a single trunk or as several roots along the lateral border of the scalenus anticus or behind it. In rarer instances the nerve may be embedded in the substance of the muscle.

Following interruption of the nerve impulses to the diaphragm there is some decrease in the vital capacity which is proportional to the height of elevation of the hemidiaphragm. The height to which the diaphragm rises depends upon the condition of the lung and pleura above the diaphragm, the adherence of the diaphragm to the surrounding tissues and the difference between the intra abdominal (usually atmospheric or positive) and intrathoracic pressure (usually negative). The vital capacity returns to about that of the preoperative state in about three months. This return to normal is the result of the increased respiratory activity of the lower third of the thorax which follows paralysis of the hemidiaphragm on the corresponding side.

Since phrenic nerve interruption has been used in such a variety of cases of pulmonary tuberculosis it is obviously difficult to evaluate the results. However, in cases of caseous pneumonic tuberculosis in which the lesions are situated in the lower half of the lung field and are not much larger than about an inch in diameter, the results are more promising. Phrenic nerve interruption has been used profitably in conjunction with pneumothorax, in which cases the lung is adherent below to the diaphragm and above in the region of the dome of the pleura. When the diaphragm becomes elevated, the tension on the lung is relaxed and the collapse by pneumothorax becomes more effective (Figs 169, 170, 171).

**Intercostal Neurectomy**—As an independent procedure intercostal nerve paralysis is less efficacious in controlling a caseous pneumonic

lesion than phrenic nerve interruption. However, there is an indication for multiple intercostal nerve paralysis. While the diaphragm is chiefly innervated by the phrenic nerve, it also receives nerve impulses from the sixth to the twelfth intercostal nerves on the corresponding side. Thus, when phrenic nerve interruption is combined with paralysis of the lower six intercostal nerves the effectiveness of the diaphragmatic elevation will be enhanced and longer lasting. I have recently employed this combined procedure in eight cases. It is too soon to evaluate the full worth of this procedure.

#### CAVITARY SURGERY

**Cavitary Suction (Monaldi)**—Monaldi observed that the wall of a tuberculous cavity is composed partly of collapsed lung tissue. His studies suggested that if negative tension in the cavity could be maintained and the bronchi leading to it remain obstructed, the pericavitary atelectatic lung would expand and thereby obliterate the cavity. Accordingly, cavity drainage was instituted by means of a catheter, the tip of which was introduced into the vomica through the chest wall. The negative tension in the cavity is adjusted according to the individual case, the maintenance of the pressure depending upon the patient's ability to withstand such tension. Since the size of the cavity varies from case to case, it was at first thought that the expansion of the surrounding lung and obliteration of the cavity would depend entirely on the relation of the degree of negative tension, the length of time it was applied to the cavity wall and the size of the cavity. Unfortunately this is not so and the inflation of the atelectatic lung which takes place soon after institution of the suction shows little lasting effects on the cavity even after many weeks of continuous drainage. Experience has shown that the results of Monaldi drainage are not encouraging.

**Cavernostomy**—Although open drainage of tuberculous cavities was performed long before the Monaldi operation was first suggested, the experiences with the latter procedure permitted greater holdness in dealing with tuberculous cavities. Chiefly from the experiences gained from this form of drainage and the fact that the patients did not develop tuberculous sinus tracks or infection of the skin and that the trauma to the cavity did not spread the disease to the surrounding lung tissue, Dr Davidson at Sea View Hospital suggested pneumonostomy with wide open drainage of tuberculous cavities. After the wall of the cavity is freed of infection and shows fresh granulation tissue, the

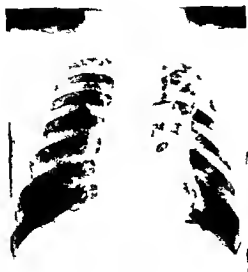


Fig 169



Fig 170

Fig 171

Fig 169—Induced pneumothorax on the left with incomplete collapse of the lung (Same case as Figs 170 and 171)

Fig 170—Incomplete collapse of the left lung by pneumothorax. Roentgenogram taken two days after the left phrenic nerve was sectioned. Note also the elevation of the left diaphragm (Same case as Figs 169 and 171)

Fig 171—One year after phrenicectomy. Pneumothorax abandoned. Cavitation controlled (Same case as Figs 169 and 170)



surrounding muscle and attached skin is transplanted into the cavity. This operation is used in patients who cannot withstand a more radical surgical procedure and in those cases in which the cavity is too large to be collapsed by thoracoplasty. The results of this operation are of equivocal value.

### THORACOPLASTY

Thoracoplasty still remains the keystone in the surgery of pulmonary tuberculosis. Preoperative localization of tuberculous cavities reveals that in more than three quarters of the cases they are in the posterior lung field. This accounts for the usual selection of the posterior (paravertebral) approach to collapse of the lung. Since the cavities are usually in the region of the apex of the lung, the operation is so designed that the maximum collapse should take place in this region.

In the selection of cases for thoracoplasty, one must evaluate preoperatively whether the patient's general condition would permit recovery from the immediate surgical procedure and if so whether he would benefit from the operation. No patient should be operated upon who is running an acute febrile course or has a spreading disease or a consolidated lung. No patient should be operated upon who has a poor cardiorespiratory reserve as evidenced by dyspnea and elevation in the pulse rate on mild exertion such as walking. No patient should be operated upon who has been entirely confined to bed for some time. No patient should be operated upon whose hemie component is low before receiving preoperative transfusions of compatible blood. Operation should be done in no case in which the anticipated final outcome is definitely poor or in which the surgical outcome gives promise of a satisfactory result but the associated complications preclude complete recovery.

Preoperatively one should estimate the extent of the thoracoplasty required to collapse the lesion. In the usual case in which the cavity is not too large (less than 5 cm) resection of two ribs below the lowermost part of the cavity usually will suffice to produce an adequate collapse (Fig 172). If there is an associated and contralateral pneumothorax and/or hydrothorax it should be aspirated as far as possible before surgical intervention is undertaken. The operation should be planned in as many stages as is congruent with the patient's general condition. The stages should not be delayed even if the sputum becomes negative for tubercle bacilli in the interim for it is not un-



Fig 172



Fig 173

Fig 174

Fig 172—Left caseous pneumonic lesion. The cavity is crossed by the fifth rib posteriorly (Same case as Figs 173 and 174)

Fig 173—Following subperiosteal resection of the upper three ribs. The cavity is now smaller and is displaced downwards and inwards and is now opposite the medial part of the sixth rib (Same case as Figs 172 and 174)

Fig 174—Following the resection of the fourth fifth and sixth ribs and the lower third of the scapula (Same case as Figs 172 and 173)

common for the sputum to become converted temporarily and then at some subsequent time to become positive again

Before the anesthesia is administered a venoclysis should be started (5 per cent glucose in saline) and continued during the operation. The needle should preferably be inserted into one of the veins about the medial aspect of the ankle. During the operation the infusion may be changed to citrated compatible blood which was drawn and prepared before the operation was started. The infusion should be continued postoperatively as long as there is any need for it. After the patient is anesthetized he should be placed on the opposite side, the side to be operated upon uppermost, and tilted anteriorly about 30 degrees so that the front of the thorax rests against a chest support.

A J-shaped incision is made about the scapula beginning opposite the second dorsal vertebra midway between the medial border of the scapula and the spinous processes of the vertebra. The vertical part of the incision extends directly caudally to the level of the eighth dorsal from which region it is extended laterally and somewhat downwards to the posterior axillary region. The underlying muscles are transected in the line of skin incision. The scapula is then elevated and the serratus magnus is detached from the chest wall, leaving about a half inch of that muscle attached thereto to allow clamping of the perforating vessels as they are cut across. The fourth rib is identified and the area crossed by the medial part of the scapula is stripped of its periosteum for a distance of about 2 inches. Dr Krynski and I have found that by means of a Balfour or preferably a Lienthal self retaining retractor, one blade of which is placed beneath the denuded fourth rib and the other along the medial and inner aspect of the scapula, the latter may be retracted without taxing the assistant's arms.

The third, second and first ribs are resected subperiosteally in that order (Fig. 173). The third and second ribs should be removed together with their respective transverse processes. The third rib should be removed anteriorly as far as the region of its cartilaginous part. The second and first ribs should be removed anteriorly at their cartilages. The transverse process of the first rib need not be removed. However, the posterior part of the rib should be removed as close to the vertebral column as is possible. In removing the first rib care must be taken not to injure the subclavian artery and vein, the brachial plexus, the internal mammary artery and the dome of the pleura.

If the cavity preoperatively was over 5 cm in diameter it is advisable to perform an apicolysis (Semb) by freeing the lung from its

surrounding attachments so as to enhance the collapse. If there was present a pneumothorax and/or hydrothorax at the time of surgical intervention, a needle should be introduced into the pleura space, outside of the operative field, and the contents aspirated until the parietal pleura in the operative area is retracted and further collapses the lung, or a moderately negative intrapleural pressure is reached.\* The surgical wound is then closed using interrupted chromic catgut No. 1 figure-of 8 sutures, plain for the subcutaneous tissue and black silk for the skin.

The subsequent stages may be performed as soon as the patient's condition warrants, preferably at two- to three-week intervals and before periosteal regeneration will interfere with maximum collapse. The conditions which must be fulfilled before the first stage is undertaken must be equally fulfilled before the subsequent stages are performed.

Because of the patient's increased debility after the first stage, subsequent stages should not be too extensive. The magnitude of each procedure should be suited to the patient's ability to withstand the operation rather than to any fixed or "routine" procedure. I always open the pocket formed above the collapsed lung, in the region of the previous operative field, and evacuate the fluid and grumous material therefrom. This, it was noted, aids in obtaining a better collapse of the lung in the following stages. If a second stage is performed about three weeks after the first, it will also be noted that there is a thick extrasosseous membrane formed over the chest wall which continues as a covering over the extrapleural pocket to the dome of the parietal pleura. If, in the second stage, this is first cut across over the sixth rib from its vertebral region as far forward as can be reached and then stripped off the chest wall as a sheath up to its attachment to the previously collapsed lung, it will form a sturdy membrane which is serviceable in controlling paradoxical respiration and aids in the collapse of the lung. This membrane, composed of fibrous tissue, may also be used in subsequent stages in a similar manner. By means of several interrupted chromic catgut No. 1 sutures this fibrous tissue is sutured to the intercostal muscle attached to the first unresected rib and to

\* If the air and fluid are left in the pleura cavity it will prevent the collapse of the parietal pleura and prevent the coaptation of the pleurae. The peritoneum which was left adherent to the parietal pleura will eventually undergo regeneration without increasing the collapse of the lung. In time, as the pneumothorax and/or fluid are absorbed, the lung will expand and become even less effectively collapsed.

the erector spinae. When this is completed one will readily appreciate its value in controlling paradoxical respiration and aid in collapse of the lung. Before the muscle is approximated in closure of the wound about 10 gm. of sulfanilamide should be dusted into the wound. The chest wall in the region of the excised ribs should be strapped snugly with adhesive tape so as to further prevent paradoxical respiration. The first stage is difficult for the surgeon because of the location of the first rib. The second stage is difficult for the patient because of his debilitated state, the added collapse of the lung and paradoxical respiration. The third stage is more difficult for the anesthetist because of the lessened amount of respiratory tissue.

The greatest volume of lung tissue collapsed at any one stage is generally observed in the second stage when the fourth, fifth and sixth ribs are removed. In contemplating two stages it is advisable to either resect five ribs or to extend the procedure to three stages and remove seven ribs. In those cases in which six ribs are removed the angle of the scapula will frequently rub against the seventh rib and cause considerable pain. Transplantation of the scapula to the inner aspect of the ribs so as to avoid the rubbing leaves an appreciable depression in the scapular region. If the indications are not to extend the operation to the seventh rib then six ribs should be removed and at the same time the lower third of the scapula too should be resected (Fig. 174).

An anterior thoracoplasty is indicated in those cases in which the residual uncollapsed cavity is suspended from the anterior part of the chest wall. In this procedure the cartilages are separated from the sternum and as much of the previously unresected and regenerated rib are removed. However the region of the pericardium should not be left unprotected by bone and cartilage. Revision thoracoplasty is indicated in those cases in which the residual cavitation is in the posterior half of the lung field and remains uncollapsed. A plane of cleavage may be readily established if part of the first unresected rib is removed. Then by blunt and sharp dissection the bony plaque of regenerated osseous tissue is removed—especially in the vertebral region and that overlying the cavity. Dr. Weinstein formerly of Sea View Hospital has shown that even after an extensive revision operation the patient's vital capacity is not remarkably reduced.

The chief complications following thoracoplasty include (1) shock and hemorrhage due to excessive trauma and bleeding (2) collection of fluid in the extrapleural space (if the suture line should become

distended, the extrapleural space should be aspirated through the front of the chest), (3) pain, especially due to injury to the intercostal nerves, (4) dyspnea and cyanosis, chiefly due to interference with oxygen exchange, (5) paradoxical respiration, an asynchronism of respiratory movement of the lung with contrary respiratory movement of the lung in the region of rib resection, (6) pulmonary infections—pneumonia and tuberculous metastases, (7) infections of the wound, (8) impairment of movement of the shoulder girdle, and (9) scoliosis.

The results of thoracoplasty reveal a fatal outcome in about 15 per cent of the cases (10 per cent in unilateral and 20 per cent in bilateral cases), failures in 15 per cent of the cases, and satisfactory results in about 70 per cent of the cases. In about half of the failures a conversion of the sputum occurs following revision, the remainder are total failures.

#### EXCISIONAL SURGERY

At the present time excisional surgery is receiving more and more enthusiastic converts, although its full value cannot be appraised as yet. There is no doubt that excisional surgery in pulmonary tuberculosis has given satisfactory results whereas if the same cases were subjected to the other procedures they would have been doomed to failure. Specifically, I refer to giant apical cavernous lesions (Figs 175, 176), large basilar cavities, massive and multiple cavernous involvement of an entire lung, post thoracoplasty residual uncollapsed cavities and the like. The extent of the operative procedure (lobectomy or pneumonectomy) should be suited to the individual case. The indications and requirements for excisional surgery in addition to the above are (1) patient's general condition is good, (2) the disease is limited to one lobe or to one lung, (3) the contralateral lung or other lobes are free of disease beyond a shadow of a doubt, (4) control by less drastic procedure, in the operator's experience, will not give a satisfactory result.

The decision to perform a lobectomy or a pneumonectomy having been made, the question of drainage of the pleural cavity arises. I prefer to institute drainage in those cases in which there was much trauma to the lung and chest wall in removal of the offending tissue. In other cases closure may be made without drainage. If drainage is instituted, on the patient's return to his bed, the tube in the chest should be connected to a subaqueous drain. If drainage is not instituted, the pleural cavity should be deflated after the wound is com-

pletely closed and before the patient is returned to his bed. The final intrapleural pressure should be equal to that of the atmosphere.

The complications ensuing upon pulmonary excision are too numerous to discuss in detail. It is sufficient to mention several of the more important ones. These are bleeding, tuberculous spread to the neighboring lung tissue, tension pneumothorax, pneumonia, atelectasis, paradoxical respiration, bronchopleural fistula, empyema, incomplete



Fig 175

Fig 175—Caseous pneumonic tuberculosis involving the right upper lobe and containing several cavities. (Same case as Fig 176.)



Fig 176

Fig 176—Coronal section of the right lung removed via pneumonectomy. (Same case as Fig 175.)

expansion of the remaining lung and cardiac decompensation. The subject of postoperative (lobectomy and pneumonectomy) complications, their recognition and treatment, will form the basis for a subsequent communication.

#### SURGERY FOR EMPYEMA

Although most of the empyemas developed by patients with pulmonary tuberculosis are related to the original disease, it should be remembered that patients with phthisis are also apt to develop nontuberculous empyema. A *pure tuberculous empyema* is nonsurgical and should be left alone unless it accumulates rapidly. At such time it should be treated by repeated aspirations under aseptic conditions. In *nontuberculous purulent empyemas*, the late Dr. Harloe at Kings

County Hospital has been able to sterilize the pleural cavity by diligent and frequent irrigations via the closed method

In the *mixed tuberculous empyema* the first step is to remove the cause of toxicity. This is accomplished by irrigation of the pleural cavity by the closed method, the catheter being passed through an intercostal space *anteriorly*, as far as possible from the site of the thoracoplasty incision (Fig 177). When the patient's condition is sufficiently improved a thoracoplasty is performed in the usual manner. (The catheter should be left in place and open at the time of

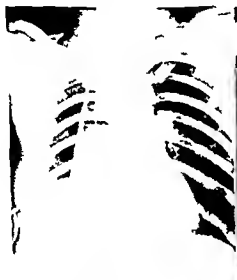


Fig 177



Fig 178

Fig 177—Right hydropneumothorax (mixed empyema). The lung is partly expanded. Note the position of the drainage tube. (Same case as Fig 178.)

Fig 178—Roentgenogram taken after thoracoplasty and Schede operations. (Same case as Fig 177.)

the operation.) However, the number of ribs resected may be more than the usual number because the lung is generally unaffected by the removal of the ribs due to the markedly thickened interposed parietal pleura. After the ribs are removed I prefer to paint the remaining periosteum with Zenker's solution so as to inhibit periosteal regeneration. The intercostal vessels and nerves, from the second downwards, should be excised—the nerve stumps should be injected with absolute alcohol in the paravertebral region.

Having taken these steps there is no urgency about the date of performance of the subsequent stages. Between the stages irrigation of



the pleural cavity should be reinstituted I have removed the upper seven ribs in the first stage thoracoplasty in patients with empyema without taxing the patient In the second stage the remainder of the ribs should be removed as well as the corresponding nerves and vessels The nerves should again be blocked in the paraverrebral region The pleural cavity is then entered and the overlying parietal pleura removed in a saucerized manner The lower intercostal muscles may be preserved and packed (not sutured) into the paravertebral gutter The pyogenic membrane attached to the surface of the lung is removed by wiping and curretting The pleurobronchial fistulas should likewise be cleaned and curretted but not enlarged The surface of the lung is then dusted with powdered sulfanilamide and the space packed loosely with gauze The wound is left open so that the progress of healing may be followed more carefully In due time the wound closes (Fig 178) If this is incomplete or leaves pockets a secondary closure may be required with transplantation of muscle into the pockets accompanied by partial resection of the scapula

## ANATOMICAL PRINCIPLES INVOLVED IN ABDOMINAL INCISIONS

FRASER B. GURD, M.D., C.M., F.R.C.S. (C.), F.A.C.S.

INCISIONS through the abdominal wall are of course not undertaken primarily in order to comply with anatomical principles, although it would appear reasonable to assume that, if the abdominal cavity may be opened without damage to essential structures, such a procedure would have advantages. It is obvious that whatever form of laparotomy would be employed its first purpose is to permit easy access to the site of the lesion for which surgical interference is being carried out, so that whatever procedure may be indicated will be possible with the least technical difficulty.

### TYPES OF ABDOMINAL INCISIONS

Theoretically, at least, the abdomen (*ab dere*—to hide) may be opened by an incision that is (1) vertical—that is to say, in a line parallel to one joining the ensiform to the symphysis pubis, (2) oblique in either direction, or (3) transverse—that is, at right angles to the vertical.

For many years in abdominal surgery vertical incisions were most generally employed and, as a matter of fact, are most frequently used at the present time. The reason for the more general employment of such wounds is that they are more readily fashioned and are satisfactory in the great majority of cases for purposes of exposure, furthermore, they are readily enlarged. As Singleton has remarked, "The long vertical incisions were at one time probably justified when intra-abdominal diagnosis was less precise, but with modern diagnosis and diagnostic agents one is rarely required to do an exploratory operation." One of the major objections to the longitudinal incision is that it is uneconomical since, as a rule, but one end of the incision is employed for exposure.

Oblique wounds are exemplified by the McBurney incision in the lower quadrant more especially on the right side, for exploration of the appendix vermiformis and the Kocher incision running parallel to

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the rib border, and most generally employed in operations upon the biliary tract

The McBurney incision, if carefully performed, is unlikely to damage any essential structure and prompt healing with a minimal risk of ultimate hernia is to be expected. The chief objection to the muscle splitting oblique wound in the right lower quadrant is that it is not easy to enlarge the opening, if such enlargement be required by the necessities of the case. The Kocher type of incision is difficult to make without running the risk of injury to three of the intercostal nerves. The modification of the oblique incision, as developed and urged by Singleton, is very satisfactory both insofar as exposure is concerned and insofar as it complies with anatomic principles. It should, however, be borne in mind that Singleton has repeatedly urged that the type of incision recommended by him is, in fact, a variant of the transverse wound which has been employed and recommended by the author for many years.

#### ADVANTAGES OF TRANSVERSE INCISIONS

There is, I believe, a practically unanimous opinion expressed by all surgeons who have learned to fashion transverse incisions in the abdominal wall that the patient's postoperative discomfort is substantially less than when vertical incisions are employed, and that healing of the wound, even though drainage has been deemed necessary, is more surely met. In consequence of the patient's greater comfort and, in fact, almost complete absence of pain due to the wound, coughing is more readily indulged in, with resultant better aeration of the lung. The practical elimination of atelectasis and other pulmonary complications in cases in which the transverse incision is used is, in my opinion, an adequate reason for the employment of this technic, even were there no other obvious advantages.

As the result of more prompt and adequate healing, the period of bed rest can be shortened substantially, wound dehiscence and eventual hernia is almost completely eliminated. At present the patients on my service in whom the transverse incision has been employed usually get out of bed as follows:

#### *Usual postoperative day-out of bed*

Appendectomy—hernia repair (Laroque)	4th to 6th day
Cholecystectomy	6th to 8th day
Gastric resection	6th to 10th day
Resection of rectum or large bowel	6th to 10th day

Singleton has reviewed 9000 consecutive abdominal operations. These have been divided into two groups, according to whether anatomic or nonanatomic incisions were employed. In the former group, in which Pfannenstiel, McBurney, modified Sloan and lateral transverse incisions were used, there were 3147 cases with one wound disruption, or 0.031 per cent, and 29 hernias, or 0.92 per cent. In the other group of nearly 6000 cases in which midline and pararectal incisions were employed there were 60 wound disruptions, or 1.02 per cent, and 131 postoperative hernias which were traced, or 2.24 per cent. Circumstances have not made it possible for us to trace our own cases, so that actual figures cannot be supplied, I believe, however, that our results would be approximately the same as those reported by Singleton.

#### USUAL CRITICISM OF TRANSVERSE INCISION AND EXPLANATION

The previous paragraph indicates that there are, in fact, important advantages to be expected when the transverse incision for laparotomy is employed. The only criticism that is ever leveled against the method is that the surgeon finds himself cramped for space in which to work, but I shall attempt to make clear that this criticism arises as a result of improperly placed incisions.

I have repeatedly urged that, whether the opening into the abdomen is to be made above or below the umbilicus, it is essential that it be made close to this structure, that is to say, within 2 or 2.5 cm. above or below, as the case may be.

Above the umbilicus, if the incision be made at the suggested point, it is easily possible in any individual case to so fashion the incision that it may reach from the tip of the twelfth rib on the one side, to the tip of the twelfth rib, on the opposite side (Fig. 179). If this be done, an incision approximately 50 cm. in length (20 inches) can be obtained in all but the smallest adult, and in many persons the circumference of the abdomen at this point permits an incision twice as long to be made. Similarly, below the umbilicus it is possible to carry the incision from the lateral edge of the quadratus lumborum muscle, on one side, to the like point on the opposite side of the abdomen. I do not wish to suggest that a wound of such dimensions is often necessary, or frequently made, but simply to point out that there should never be any risk of being short of room in which to work. The opening suggested above, which may be described as the maximum

optimum incision, damages no essential structure which does not promptly heal.

If, in operations upon the biliary tract or stomach, an incision is made across the abdomen, five or more centimeters above the umbilicus, it is clear that the rib borders on both sides of the abdomen will be encountered while the incision is still too short to permit facility in performing the operative procedure. Similarly, if the incision be made below the anterior superior spine, although a substantial

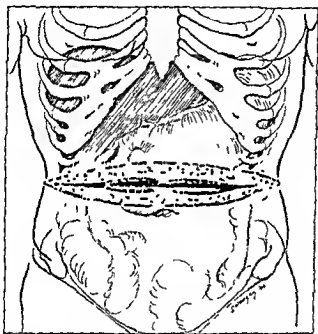


Fig. 179—The maximum optimum incision above the umbilicus. As indicated in the text, an incision of this magnitude is rarely necessary but is always available.

wound may be obtained, it cannot be extended into the loin on either side.

In addition to the limit to the length of incision which is possible in this way through the fact that the bone and cartilaginous structures of the body are encountered, several important anatomic facts influence the surgeon in placing the wound close to the umbilicus. These are especially due to the fact that within 25 cm. of the umbilicus, whether above or below, the fibers of all three oblique muscles never vary from the horizontal more than 35 degrees, so that there is little

or no likelihood of having to cut the fascia across any of its fibers. Furthermore, below the umbilicus the posterior sheath of the rectus ceases to exist at the fold of Douglas and apparently it is of value to have this structure available in closing the abdomen. As in the case of the muscle and aponeurotic fibers, as referred to above, the direction of nerves and the intercostal blood vessels in this part of the abdomen is approximately transverse, therefore the risk of damage to them is minimal.

It will readily be admitted by all advocates of the transverse incision that a few minutes more operating time are required to enter the abdomen by this means than by a midline incision through the linea alba, and that although closure is accomplished with less embarrassment since sutures do not cut out, it is probably true that a few minutes longer may be required to close the wound.

One important advantage in the opinion of many of us is that, since coughing and retching tend to approximate the wound edges and not to tear them apart as is the case with the vertical incision, light weight sutures whether silk (c-0), cotton (46), catgut (000), or other material, are sufficient for purposes of wound closure. This is not the place to enter into a discussion regarding the relative advantages of fine as compared with heavy material, there is, however, I believe, much evidence available to support the use of light weight sutures and ligatures.

It can, I believe, be accepted as a general principle in the performance of operations on any part of the body that muscle tissue may be incised transversely with impunity so long as, on the one hand, the nerve supply to the muscle is not damaged and on the other hand the fascial or tendinous part of the musculotendinous system is not seriously injured. This we prove several times every week in the performance of thoracoplasty for pulmonary tuberculosis, an operation in which all the muscles attached to the medial and lower borders of the scapula are divided transversely.

The nerve supply of both the oblique muscles and the recti is such that even with the most extensive transverse incisions there is no danger of damaging more than one of the intercostal nerves. Since there is adequate proof that unless three consecutive nerves are destroyed paralysis of the muscles of the abdominal wall does not take place it is evident that there is no risk of weakness due to this cause. Experience in the use of such wounds over a period of almost thirty years and in thousands of cases has proved this to be true.

## ANATOMIC BASIS FOR TRANSVERSE INCISIONS

Theoretic misunderstanding with regard to the safety of the transverse incision has arisen owing to the fact that the extensions of the aponeuroses or tendons of the oblique muscles, both superficial and deep, have been referred to in textbooks of anatomy, and especially surgery, as the rectus sheath. Since the fibers of the muscle extend perpendicularly from the neighborhood of the symphysis pubis to the rib borders in the neighborhood of the ensiform cartilage many surgeons have assumed that the aponeuroses which envelop the muscle run in the same direction. As a matter of fact, the

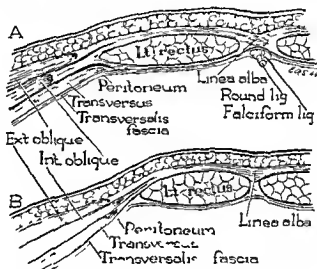


Fig. 180—Cross sections of the abdominal wall *A*, above the umbilicus, *B*, at the semilunar fold of Douglas

muscles are placed between the aponeuroses (tendons) of the oblique muscles which fuse with one another in the linea alba (Figs 180, 181). Posteriorly the rectus is attached very loosely to the aponeurosis, though anteriorly at three or four points—the lineae transversae. Anteriorly the rectus is attached somewhat intimately.

This is, perhaps, a suitable point at which to state that, after transverse division of the rectus muscle at either of the sites recommended, if careful suture of the anterior and posterior leaves of the rectus sheath be accomplished the muscle never exhibits any tendency to retract. Nor is there any merit in the introduction of fixation sutures, such as has been recommended in the past. I have moreover proved

my own satisfaction that staggering of the wound (Barlett) or the performance of complicated incisions such as those of Sloan and Singleton are unnecessary, although all of these wounds are better, in my opinion, than vertical incisions

The most recent summary of operations of "General Surgery" is that by Professor T E Orr, of the University of Kansas In this excellent volume Orr indicates and illustrates most of the abdominal incisions which have been employed on this continent, at least in recent years Among the incisions so discussed are the pyramidal, mid-

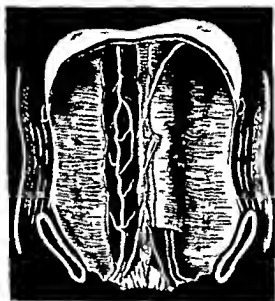


Fig 181—Diagram illustrating the deep surface of the anterior abdominal wall This drawing shows the direction of the fibers of the transversalis fascia including the posterior sheath of the rectus (Author's article in *Operative Surgery*, F W Bancroft Appleton Century Co)

line, the Battle, those of Clute, Mason, Sloan, Singleton, Pfannenstiel, the McBurney and its modification by Weir With reference to the transverse incision Orr, both in his illustrations and text, makes the usual common mistake, namely that the incision is placed too high on the abdomen so that, as indicated elsewhere in this contribution, a short incision only is possible He makes the statement, also, that tension mattress sutures are placed at least 1 cm from the wound margins through the anterior sheath and rectus muscle, on each side The very fact that the word tension is employed is proof, I believe, that a proper appreciation of the ease with which the aponeuroses, both deep and superficial, involving the rectus can be brought together has not been



appreciated by him. Sutures should not be placed in the rectus muscle. If the two aponeurotic layers are carefully coapted the cut surfaces of the muscle are brought into contact.

### TECHNIC OF TRANSVERSE INCISIONS

**Upper Quadrants**—Directions given in this contribution are intended for right handed surgeons. When operations are to be undertaken in either of the upper quadrants of the abdomen (Fig 182), the surgeon stands on the right side of the patient whether the biliary tract, hepatic flexure, the stomach, the spleen or splenic flexure is the site of inter-

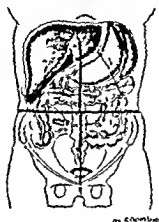


Fig 181—Diagram showing the four quadrants of the abdomen with viscera usually found in each. (Author's article in *Operative Surgery* F W Bancroft Appleton Century Co.)

ference. When the structures involved lie in the right upper quadrant the incision is begun a short distance to the left of the midline and extended into the loin in the direction of the tip of the twelfth rib. Although the indicated procedure may frequently be easily performed by retraction of the muscle toward the midline without division there should never be any hesitation in complete division of the right rectus, the linea alba and whatever portion of the left rectus is necessary to give easy access to the field of operation. In operations upon the spleen and splenic flexure incision is made through the left side of the abdomen followed as required by division of the left rectus and splitting of the oblique muscles on the left side. Incision of the linea

alba and right rectus should be carried out if greater freedom is deemed advisable

**Lower Quadrants**—In operations of any considerable magnitude in the lower abdomen, such as abdominoperineal resection of the rectum (Fig 183), resection of the sigmoid and descending colon and total hysterectomy, it is recommended that the surgeon stand on the left side of the patient and that the incision be commenced over the left lower quadrant but above the fold of Douglas

**Appendectomy Incision**—By long odds laparotomy is most commonly done for removal of the appendix vermiformis. In order that this may

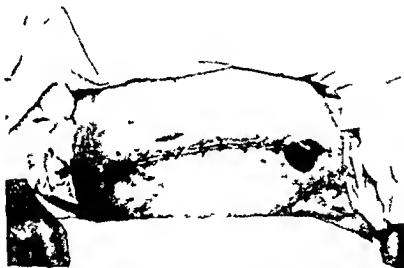


Fig 183—Completion of the abdominal part of an abdominoperineal resection of the rectum. Shown are the site of incision recommended and placement of the permanent colostomy.

be adequately carried out, the incision should be over the right lower quadrant. The incision which I have employed since 1916, and which was described in 1929, lies absolutely transverse, its medial end at, or close, to the midline approximately 2 cm below the umbilicus (in the adult), and extends outward so as to be easily continued above the iliac crest (Figs 184, 185). As a rule the rectus muscle together with the eleventh intercostal nerve is displaced toward the midline. In all but the smallest persons it is possible, in this way to obtain a sufficiently large opening into the abdomen to permit the hand to be introduced and adequate manual exploration at least, of the gall-bladder, the pancreas, pelvic organs and other parts of the abdomen accomplished. With rare exceptions the ascending colon, close to the

cecum, presents and the cecum, together with the terminal ileum and the appendix, may be drawn up into the wound. In acute cases with peritonitis, if a saline pack is inserted, the small bowel except for the terminal ileum need never be seen. I am convinced that any surgeon who has learned to make such an incision for exploration of the right lower quadrant will never again employ the McBurney, Battle or other incision. If a sufficient amount of room is not available by simple dis-

Fig 184

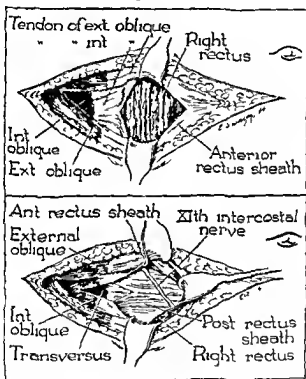


Fig 185

Figs 184 185—Technic of the author's incision for appendectomy

placement of the rectus there should be no hesitation about division of the right rectus and linea alba and as much of the left rectus as may be required. I wish here to reiterate that almost thirty years experience with this incision has convinced me that weakness of the abdominal wall does not result.

For many years I have made it a practice when the diagnosis of appendiceal disease has been made in persons over 40 years of age

more especially women, to make the incision above the umbilicus. This is done not only for an adequate visualization of the gallbladder and duodenal region, but also in order that whatever interference is deemed advisable for disease of these organs may be carried out. It is unusual to meet any difficulty in performing a satisfactory appendectomy through such an incision. When such difficulty is experienced the wound is enlarged as may be required.

**Detailed Technic of Upper Abdominal Incision**—It is not necessary in this contribution to detail the incision required for exposing all four quadrants of the abdomen, that which is used for operations upon the biliary tract or for the resection of the stomach is, therefore, described.

A transverse incision is made through skin and subcutaneous fascia. This commences from 2.5 to 7.5 cm. to the left of the midline and is carried to approximately the tip of the twelfth rib, on the right side. The incision is made about 2 cm. above the upper border of the umbilicus. At this point the middle transverse line is usually above the line of incision.

The wound is carried down to the anterior sheath of the rectus and the external oblique muscle and aponeurosis. A few bleeders are encountered. These are clamped and it is unusual to find it necessary to apply ligatures.

The aponeurosis covering the rectus muscle, which is made up over its medial half to two thirds of the fused aponeurosis of the external oblique and the superficial half of the aponeurosis of the internal oblique, is incised transversely. Since the fibers so divided run almost horizontally across the abdomen, there is no danger of cutting across the lines of stress.

The lateral portion of the aponeurosis of the external oblique muscle is split in the direction of its fibers out to the rib border and, if deemed necessary in the individual case, in part cut away from this fixed structure (Fig. 186).

The external oblique is then retracted upward and downward and the somewhat thin fascia covering the internal oblique muscle incised well into the loin. If the primary purpose of the operation is exploration of the upper abdomen with the probability that no interference other than appendectomy will be required the rectus muscle is separated by sharp dissection from the anterior aponeurosis for a distance of about 15 cm., both upward and downward. As indicated elsewhere, the posterior surface of the rectus muscle is not attached to the aponeurosis, it can, therefore, be easily and widely separated.

The rectus muscle together with the ninth intercostal nerve, which is clearly seen lying somewhat loosely on the anterior surface of the posterior aponeurosis, is retracted toward the midline.

If the wound is then firmly elevated towards the ceiling the posterior aponeurosis, along with the peritoneum, is opened by a sharp cut with the belly of the scalpel in the direction of the fibers of the former. The negative pressure produced inside the abdomen by elevation of the anterior abdominal wall makes it safe to enter the abdomen in this

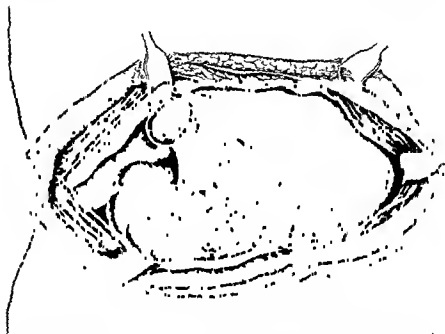


Fig. 186 Exposure obtained with the incision above the umbilicus when the right rectus has been divided, the oblique muscle split into the loin, and, after division of the linea alba, the left rectus is retracted

way unless previous laparotomy, or other similar lesion has been followed by fixation of the abdominal viscera to the deep surface of the peritoneum

The posterior aponeurosis and peritoneum are incised as far toward the midline as is convenient and the internal oblique and transversus torn open into the loin by means of the fingers. If the aponeurosis covering the anterior surface of the internal oblique has already been incised this maneuver is accomplished with the employment of but little force, and practically no risk of damage to either nerve or blood vessel is encountered

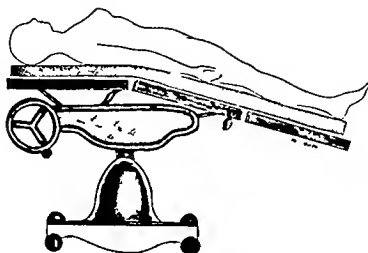


Fig 187

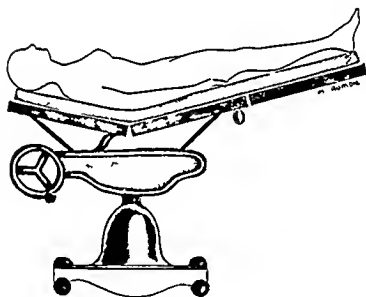


Fig 188

Figs 187 188—Method of breaking the operating table so that visualization of the extrahepatic bile ducts may be made easier and the method employed of jack knifing the table during closure of the transverse incision. When this method is used suture of the different layers may be accomplished with ease (Author's article in *Operative Surgery* F W Bancroft Appleton Century Co)

Through such an incision it is almost invariably possible to examine adequately the stomach and duodenum pancreas and biliary tract and manually to palpate the pelvic organs as well as other parts of the

abdomen. Rarely is any difficulty experienced in displacing the wound downward sufficiently to make appendectomy easy.

When interference with the bile ducts, resection of the stomach or right hemicolectomy is necessary, large Kelly clamps are placed upon the rectus muscle, above and below the line of incision, and the muscle is divided between them. The incision is then carried through the linea alba and falciform and round ligaments and continued on the left side of the abdomen as far as may be required to give adequate exposure for easy operation.

The operation of total resection of the stomach (for carcinoma) is always difficult, if, therefore, in such a case the cardiac orifice is not readily exposed there should be no hesitation in increasing the exposure by a midline incision which may quite properly extend to the ensiform or may be turned toward the left, as recommended by Clute and the rib cartilages divided. When this is done the maximum exposure of the inferior surface of the left diaphragm is obtained.

When the incision is carried across the midline one or possibly two vessels in the falciform ligament require ligation. If the Kelly clamps are allowed to remain in the rectus for five minutes or longer as a rule only one artery (the internal mammary or deep epigastric) will require ligation on both cut surfaces.

### CONCLUSION

The criteria of a satisfactory abdominal incision, I believe, are (1) adequate exposure, (2) conservation of strength of abdominal wall, (3) postoperative comfort, (4) ease of fashioning, (5) simplicity of closure and (6) absence of unsightly scar. Sufficient proof has been given in this short contribution to support the contention that these criteria are more usually met by the employment of a transverse incision, suitably placed, than by other methods of performing laparotomy.

## ACUTE CHOLECYSTITIS

The Surgical Treatment of 332 Cases at The Presbyterian Hospital,  
New York 1932-1941 Inclusive

BEVERLY CHEW SMITH, M.D., F.A.C.S.\*

In the past decade the surgical therapy of acute cholecystitis has tended towards earlier operation and preferably cholecystectomy. Cholecystostomy—formerly regarded the more conservative procedure—has been shown to have a higher mortality than cholecystectomy. This is largely because it is performed on sicker patients in whom delayed therapy has permitted the complications of acute cholecystitis and their systemic effects to become clinically evident.

The local etiologic factors recognized today in this disease are concentration of bile infection of the gallbladder wall from organisms in the bile or borne to the wall by lymphatics and obstruction to the outflow of bile from the gallbladder.

The pathologic changes in most cases of acute cholecystitis result when a stone becomes impacted in the cystic duct or ampullary region interfering with venous, arterial and lymphatic circulation at that site, from which these circulations through the remainder of the viscus are largely controlled. Distally ischemic and edematous areas become infected, necrose and perforate. Pathogenic organisms are recovered more frequently from the gallbladder wall than from the bile. Edema and lymphangitis spread through the gastrohepatic omentum, common duct wall and its lymphatics to regional lymph nodes, into the liver, pancreas and upper retroperitoneal tissues.

Gangrene, perforation, pericholecystic abscess formation and diffuse peritonitis may develop, increasing the mortality. The surgical attitude has been that the acutely inflamed gallbladder frequently subsides to a 'chronic' state and that the mortality following its removal in this quiescent condition is lower than if it is removed early.

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## HISTORICAL NOTES

Acute cholecystitis is a relatively old clinical entity but cholecystectomy was first performed for chronic cholecystitis by Langenbuch on July 15, 1882. On May 15, 1900, Lihenthal did the first of a series of thirteen cholecystectomies with one death (a six months' pregnant patient) for acute cholecystitis which he reported in 1904.

Ochsner in 1902 believed it was unwise to operate during the acute stage. Richardson, the same year, stressed the disadvantages of ectomy for acute cholecystitis, as leaving no possibility of drainage of the biliary passages, except through one of the ducts, and that only after difficult and unsatisfactory operation, greater danger in the operation and the extremely difficult and unsatisfactory redrainage of the biliary passages.

W. J. Mayo in 1902 collected reports of 2000 cholecystostomies done by six surgeons without instance of reformation of calculi. German surgeons from 1920 to 1930 favored delayed operation. Judson and Lyons at this time concurred.

Enderlen and Hotz in 1923 advocated postponing operating during the acute period and felt that early operation was indicated only if changes for the worse were progressive.

Bland-Sutton in 1924 thought it reprehensible *not* to remove the acute gallbladder immediately. Kirschner in 1924 advocated early operation. Crile was impressed by cures when acutely inflamed gallbladders were removed. Leriche and Cott, Miller, Alexander, Mentzer, Zininger and Finney favored early operation. Thus through controversy has the present surgical attitude toward acute cholecystitis emerged.

Cave in 1926, concluded from a sixteen year study of 575 gallbladder operations that he would not advocate cholecystectomy for acutely inflamed gallbladders and that he preferred cholecystostomy. Deaver in 1926 favored delay.

Haggard, Archibald, Dean Lewis, McGuire, Richardson and Brugesman, as late as 1928, favored delay and thought indications for operation for acute cholecystitis were rarely present.

Whipple in 1930 reviewed 160 cases at Presbyterian Hospital in the sixteen years preceding this report, and concluded "Only a surgeon operating on acute biliary lesions has any conception of the difficulties encountered in these cases. Associated obesity, septic state, anesthetic difficulties, unsatisfactory and hurried operations because of pathology and the condition of the patient, the high mortality, the persisting

symptoms, mucous fistulae after ostomies, and the necessity of secondary cholecystectomies, are factors tending to convince careful and conservative surgeons as well as physicians of the advantage of removing these foci of infection at a time when the patient is in good physical condition and prepared for the operation of cholecystectomy."

Heuer (1934) in a review of 36,623 cases from the literature, found gangrene and perforation accounted for 10 per cent, consequences of surgical procedures (shock, peritonitis, hemorrhage and ileus) attendant upon advanced pathology 33 per cent, pulmonary complications 20 per cent and cardiorenal complications 12 per cent of the mortality in the entire series. These figures stress the disaster of largely preventable complications.

Heuer again in 1936 concluded from a study of 305 cases of acute cholecystitis from two hospitals that it was frequently impossible from clinical manifestations to visualize accurately the course of the inflammatory process in the gallbladder, that gangrene and perforation may exist or occur in the presence of subsiding symptoms and that they occur too frequently to be disregarded—the incidence of gangrene and perforation being probably 20 per cent. He further stated that danger from operation at any stage before perforation has been over-emphasized and is distinctly less than the dangers of gangrene and perforation that are the result of a waiting policy.

Heuer advocated early operation as a safer method in the majority of cases. He admitted, however, that delay, usually in the middle or old age group, in order to improve the patient's general condition may be wiser in certain cases than a hasty operation.

Pennoyer in 1937, reviewing a series of 300 consecutive cases of cholecystitis from Roosevelt Hospital, concluded that operation upon acutely inflamed gallbladders in all patients gave a much higher mortality than delayed operation and that the major cause of death was not peritonitis or the natural course of the disease, but postoperative complications.

Graham and Hoefel, in 1938, concluded from a series of 167 cases of acute cholecystitis in which operation was done within forty-eight hours of onset of symptoms, with a mortality of 3.59 per cent, that earnest consideration should be given to cholecystectomy during the first day or two of an acute attack.

Berk in 1940, collected 3863 cases of acute cholecystitis from seven teen clinics, 92.5 per cent had calculi in the gallbladder. *Eight clinics which observed 961 cases from one to twelve days reported that 73.5*

*per cent subsided. Empyema occurred in 19.1 per cent of 3720 cases and generalized peritonitis in 2.3 per cent of 3096 cases*

*The mortality after "early" operation was 16.4 in 1744 cases from eighteen clinics. The mortality following conservative treatment with and without operation was 5.6 per cent in 2202 cases from nine clinics. Thus, from the literature, he statistically found a mortality three times greater among the patients treated by early operation as compared with those observed and operated upon late. The terms "early," "late," "immediate," "delayed" and "conservative" are used throughout the literature confusedly. More authority could be attached to statistics stated in hours or days.*

Lord Moynihan has stated that surgery of the gallbladder is difficult, sometimes extremely difficult. Says he: "I hold it to be of greater technical difficulty and to present more problems for immediate accuracy of judgment than any other branch of surgery. If I might presume to offer any advice to the surgeon who has not had the opportunity for great and continued practical work, I would suggest to him to leave surgery of the gallbladder alone."

#### PRESENT ATTITUDES

Historically, the surgical treatment of acute cholecystitis perhaps resembles that of acute appendicitis in that surgical therapy in the latter was at first for the acute appendicitis plus complications of perforation, abscess and peritonitis. Surgeons soon learned that *the mortality was less if the acute appendix was removed before complications occurred.* Acute appendicitis is now recognized early and patients seek therapy shortly after onset of their symptoms. The surgical treatment of the complications of acute appendicitis like those of acute cholecystitis, however, are still a difficult problem.

Patients with an acute inflammation of the gallbladder have not learned to come for surgical therapy as quickly as do those with an acute appendix. Medical men frequently do not realize the necessity for early surgery. They have watched surgeons observe these cases in hospitals for days before operation, consequently, they have observed them in their homes rather than hospitalize them at the onset of symptoms. This results in the eventual admission of patients whose symptoms have been present for days, with complications that make surgical therapy more difficult. It is the treatment of these complications that increases the morbidity and mortality in this disease.

When an acute case has not improved in twenty-four to forty-eight

hours of hospital therapy, should its surgical treatment be approached with a determination to perform cholecystectomy? If there is no compromising pathologic condition elsewhere, this may be justified, but I do not think it is a sound principle to teach. The validity of this doubtful attitude is supported by the too frequent surprise of the operator at finding more advanced pathologic changes than he expected.

I daresay that if the resident surgeons in hospitals today were asked to outline the treatment of acute cholecystitis the majority would state that *cholecystectomy is indicated as early in the disease as possible provided the patient is adequately prepared and there are no systemic contraindications to operation*. This has been the attitude of the Surgical Resident Staff at the Presbyterian Hospital during the past five years, and it has provided me with an opportunity to observe the cases as a consultant in postoperative therapy. I did not see the case preoperatively, and was *not present* at the operation. I often found myself anxious about the patient's early postoperative condition, questioning the advisability of such extensive surgery in the acute case and at times defending indications for cholecystostomy, which younger surgeons seemed either to have overlooked or forgotten in their zeal for complete surgical therapy. *I feel there should be justification for the use of a specific surgical procedure in the individual case, and that it should not be used because it is the accepted procedure of the moment*. There is needed a background of judgment tempered by consideration of the patient's condition as well as the conflicting views concerning the particular problem at hand.

#### ANALYSIS OF 332 CASES OF ACUTE CHOLECYSTITIS TREATED SURGICALLY AT THE PRESBYTERIAN HOSPITAL 1932-1941

I have approached this analysis with a background of having been exposed to the teachings of both schools of early and delayed operation. The cases studied have had the accepted facilities for preoperative and postoperative therapy, the benefit of various anesthetics, modern methods of combating shock, the use of oxygen in respiratory diseases and of the sulfa drugs, and twenty-five years experience of a follow up clinic that personally interviews 98 per cent of the cases operated on. I am aware also of the clinical difficulties of determining the exact pathologic condition of the acute gallbladder from signs, symptoms and laboratory data. In consequence, in acute cholecystitis (as in other surgical lesions) the condition of the patient or the lesion itself may definitely indicate one therapy in one group of cases, an-

other group of cases may be hopeless regardless of any therapy, while a third, and very important group, comprises those patients in whom proper therapy executed at the proper time plus adequate adjuvant therapies means the difference between recovery and death.

This series comprises 332 cases of acute cholecystitis from the Surgical Wards of the Presbyterian Hospital which I have personally abstracted. One hundred eleven of the patients (33.6 per cent) were males and 221 (66.4 per cent) were females. Of the 221 females, 133 (60 per cent) had undergone one or more pregnancies.

#### SURGICAL PROCEDURE AND MORTALITY

	No. of Cases	Deaths	Mortality Per Cent
Cholecystectomy	273	8	3.5
Cholecystostomy	103	12	11.6
Exploratory celiotomy—no gallbladder operation	2	2	
Choledochostomy—no gallbladder operation	1	1	
Acute gallbladder found at postmortem	1		
Celiotomy—exploration of gallbladder—no gallbladder operation	1		
Appendectomy—no operation on acute gallbladder	1	1	
Totals	332	24	7.2

#### AGE INCIDENCE

Age	No. of Cases
10-20	2
20-30	19
30-40	82
40-50	78
50-60	75
60-70	49
70-80	24
80-90	3
	332

**Mortality**—There were twenty-four deaths, a mortality of 7.2 per cent. One death occurred without operation. Of the twenty-four deaths, twenty occurred in patients over fifty years of age. Twenty per cent had either gangrene or perforation or perforation with abscess. Seven died with acute pulmonary, five with cardiac and two with renal complications. One patient died of a sepsis from infection of the operative field caused by a clamp slipping off the cystic duct. Two died of pulmonary emboli. One patient with this complication survived. One died of apoplexy. Two succumbed to hyperpyrexia.

**Diagnostic Data**—Upon admission 228 of the patients (72 per cent) had had one or more previous attacks and 135, or 40 per cent, had had many attacks. Seventy-seven (23 per cent) were jaundiced. In six cases of acutely inflamed intrahepatic gallbladder, the signs were minimal. One should bear this anatomical anomaly in mind when the symptoms are out of proportion to the signs.

Deductions from the white and differential blood counts were not conclusive except that one above 20,000 was frequently associated with infection under tension, gangrene, edema or pericholecystitis. These same complications were found, however, with a white blood cell count as low as 5000 with 65 per cent polymorphonuclear cells. Most of the cases with low counts did not show marked signs of toxemia and operation was delayed. A white blood cell count of 20,000 or more should suggest complications demanding emergency surgery. It occurred in twenty instances. These patients were operated upon on the day of admission, advanced and probably irreversible pathologic changes being found.

Of 121 flat abdominal x rays taken for gallstones, fifty-six (46 per cent) were positive. Of sixty-four cholecystograms taken during observation, sixty-three were positive for stone or poor function.

Physical examination revealed a tender mass in the right upper quadrant in 110 cases (35.8 per cent).

Although acute cholecystitis may often be evident clinically, the diagnosis, particularly when disguised by other preoperative pathologic conditions, may be most difficult. In this group a diagnosis of coronary thrombosis, pleurisy, ruptured duodenal or gastric ulcer, infected hydronephrosis with renal calculus, perforated diverticulitis and carcinoma of the transverse colon, pancreatitis and appendicitis was made by experienced observers and the patients treated for these conditions in the wards before acute cholecystitis became obvious. The greatest difficulty of diagnosis occurs when patients are seen within twelve hours of the onset of symptoms.

**Preoperative Pathologic Findings**—One hundred and ninety-five patients (58.9 per cent) had preoperative pathologic conditions which influenced their surgical therapy as follows:

Obesity	104 (31%)
Cardiac decompensation	16
Diabetes mellitus	13
Hypertension	12
Early convalescence from other surgery	7

Pregnancy	6
Pleurisy	5
Ulcerative colitis	2
Senility	6
Pancreatitis	5
Respiratory disease (pneumonia, bronchitis, emphysema, asthma, bronchiectasis)	6
Cerebral sclerosis	2
Malnutrition	1
Fibroids of the uterus	1
Cirrhosis of the liver	1
Acute parotitis	1
Tuberculosis of the peritoneum	2
Carcinoma of the stomach	2
Diseases of the blood (polycythemia thrombocytopenic purpura, pernicious anemia)	3

In the following instances the diagnosis was difficult: Acute cholecystitis occurred on the third day after repair of a postoperative ventral hernia in the right lower quadrant, on the third day following repair of a right inguinal hernia, in a patient with a fractured neck of the femur who was in a spica, in a convalescing patient with compound fracture of the tibia who was in a cast to the groin, during convalescence from ureterolithotomy, four days after cesarean section, during sepsis from hemolytic streptococcus gangrene of the scrotum, in a case of carcinoma of the breast, in which a mass in the right upper quadrant thought to be liver metastasis was found to be an acute gall bladder surrounded by omentum, and during convalescence from a coronary thrombosis.

#### ANESTHESIA

	No. of Cases
Gas, oxygen and ether	109 (33%)
Spinal	70 (21%)
Local	50
Avertin nitrous oxide and ether	78
Cyclopropane alone or with ether and avertin	20
No gallbladder operation	3
	<hr/> 332

#### SUTURE MATERIAL

	No. of Cases
Cargut	294 (90%)
Silk	30
Cotton	2

(In one case several silk sutures were extracted from the wound. Otherwise there were no complications from the use of either silk or cotton.)

## TIME OF OPERATION

239 cases (70%) were observed for one day to five weeks after admission before operation 24 died Mortality 10%  
 92 cases (30%) were operated on day of admission 5 died Mortality 5.4%  
 75% of the cases had had one or more—usually many attacks before admission  
 25% were admitted during the first attack

## OPERATION IN 54 CASES WITH ADVANCED DISEASE

	Cases	Death	Mortality
Cholecystectomy	26	2	7.6%
Cholecystostomy	28	2	7.1%
	<u>54</u>	<u>4</u>	<u>7.4%</u>
Gangrene 54 cases (16.4%)			
With perforation			30 (9.1%)
With abscess			18 (5.4%)
With empyema			6 (1.8%)
			<u>54 (16.4%)</u>

## WOUND DISRUPTIONS AND HERNIAS

Type of Incision	No of Cases	Disruption	Hernias
Transverse	260	5 (1.9%)	11 (4.2%)
Right rectus (split)	68	4 (5.8%)	4 (5.8%)

## GROSS PATHOLOGY

	No of Cases
Calculi in gallbladder	314 (94.5%)
Calculi in common duct	19 (5.7%)
No calculi found at operation	18 (5.4%)
Gangrene	54 (16.4%)
Perforation	30 (9.1%)
Pericholecystic abscess	16 (4.8%)

## TYPE OF DRAINAGE USED IN 223 CHOLECYSTECTOMIES

	No of Cases
Rubber tube to Morison's pouch	150 (76.0%)
Penrose tube to Morison's pouch	38
Cigarette drains to Morison's pouch	33
Silk tampon drain into which cigarette drains were placed with a rubber tube to Morison's pouch outside of tampon	<u>2</u>
	223



**Bacteriology.**—In 100 (30 per cent) of the cases, no cultures were mentioned on the charts, indicating no cultures had reached the laboratory.

Of the 228 that were cultured, 20 per cent were reported "no growth" Other cases showed

<i>B. coli</i>	70 times
<i>Streptococcus viridans</i>	23
Welch bacillus	10 "
Hemolytic streptococcus	5 "
<i>Staphylococcus aureus</i>	7 "
<i>Pneumococcus</i>	3
Hemolytic <i>B. subtilis</i>	8 "
<i>Typhoid bacillus</i>	7 "

There were often several organisms recovered from one culture

**Postoperative Temperatures**—The postoperative temperatures within the first forty-eight hours in the 223 cholecystectomy cases were as follows

Not over 101° F	45 cases (20.1%)
101° to 103° F	67 " (30%)
103° to 104° F	64 " (28%)
104° to 105° F	34 " (15%)
105° to 106° F	11 " (5%)
108° F	2 " (died) (1%)

Within the first forty-eight hours 111 patients or 49.7 per cent of all undergoing cholecystectomy had a postoperative temperature of 103° to 108° F

Allen reports that 202 of 415 patients undergoing cholecystectomy for acute cholecystitis had a postoperative temperature over 102° and eighty-eight over 103°. Thus the postoperative temperatures of 290 patients ran between 102° and 103°, indicating a rather sharp postoperative reaction

**Operative Accidents**—Local contamination occurred twelve times during cholecystectomy when the gallbladder was accidentally ruptured during its removal without previous aspiration. Other accidents mentioned were

Clamp slipped off the cystic duct on the gallbladder after division of the duct permitting local contamination which in one case was the cause of a peritonitis which went on to sepsis and death

Clamp or ligature came off of the cystic artery in three cases.

Bleeding from the gallbladder bed when the viscus was re-

## POSTOPERATIVE COMPLICATIONS IN 331 CASES TREATED BY OPERATION

1 Pulmonary 45 cases (13.6%) of all operated cases	
Pneumonia	36 (10.8%)
Atelectasis	4
Edema	2
Embolus	2
Positive tuberculous sputum	1
2 Ileus 9 cases (2.7%)	
Paralytic	6
Mechanical—of duodenum	1
Acute gastric dilatation	2
3 Cardiac 8 cases (2.3%)	
Failure	6
Coronary occlusion	1
Pericarditis requiring pericardiectomy	1
4 Shock requiring treatment	6
Profuse bile drainage	6 (6%)
Mucous fistulas after ostomy	6
5 Disruptions	9 (2.1%)
Acute pancreatitis	5 (1.5%)
Subphrenic abscess	4
Genito urinary 7 cases (2.1%)	
Uremia	2
Anuria	2
Cystitis	2
Acute retention—enlarged prostate	1
Cerebral	
Hemorrhage	1
Thrombosis	1
Venous	
Suppurative phlebitis	1
Thrombophlebitis	1
Chills of undetermined origin	3
Postoperative hemorrhage	1
Prolonged hiccoughs	1
Bacteriemia (B. coli)	1
Parotitis	1
Postoperative pain of undetermined origin	4

moved from the fundus down was definitely troublesome in obscuring the operative field in twelve instances

Difficult exposure resulted from a sharp costal angle, an abnormally low liver, an abnormally high liver and obesity

Operative shock occurred six times in 331 operated cases (1.8 per cent)

Once a large fibroid was adjacent to an acutely inflamed gall bladder necessitating an ostomy rather than ectomy Twice the

gallbladder was pulled from the duct and liver bed without bleeding or drainage of bile

The common duct was inadvertently injured five times but these injuries were no more serious than accidental opening into the duct. In no cases was the duct divided.

In two instances the gallbladder could not be found.

In one case bleeding from the liver (injured during removal of the gallbladder) was difficult to control.

In three cases it was so difficult to get the gallbladder out of its bed in the liver that only a partial cholecystectomy could be done. It is suggested that the mucous membrane left in such cases might be destroyed by heat or chemical cauterization.

In one case the hepatic artery was aspirated for the cystic duct.

The duodenum was accidentally opened twice.

The factors which contributed most to the operative accidents were edema masking normal structures and anomalous anatomy of the duct and arterial systems. Because of edema in the ampullary, cystic, common duct and gastrohepatic regions the cystic duct and artery could not be distinguished four times; the common duct could not be found twice and the facility of the operation was impeded *twenty three times* or 7 per cent of all operated cases.

*A serious postoperative complication occurred in one hundred and twenty (36.2 per cent) of the 331 cases in which operation was done.*

**Wound Disruptions**—Five transverse wounds disrupted (two cholecystostomy, three cholecystectomy). There were six hernias in transverse incisions besides the five which disrupted—or eleven hernias in all.

ANALYSIS OF WOUND DISRUPTIONS

Operative Procedure	Incision	Disruption of Wound—Days Postoperative	Coincidental Postoperative Complication
Cholecystectomy	Transverse	9 days	Pneumonia
Cholecystectomy	Transverse	8 days	No evidence of wound repair
Cholecystectomy	Rt. rectus	5 days	Pneumonia
Cholecystectomy	Transverse	2 days	Tampon drain
Cholecystectomy	Rt. rectus	12 days	Bronchopneumonia, gastric dilatation
Cholecystostomy	Rt. rectus	6 days	Bronchopneumonia
Cholecystostomy	Rt. rectus	8 days	Pneumonia
Cholecystostomy	Transverse	9 days	Obesity, pneumonia
Cholecystostomy	Transverse	9 days	Pneumonia

Four right rectus incisions had wound disruption (two cholecystostomy and two cholecystectomy) No hernias occurred in this group except in those with disruption

All right rectus and transverse incisions which disrupted were followed by hernia Five other transverse incisions developed hernia because of pulmonary complications, tampon drainage or loose closure of wound about drainage tube

#### WHEN TO OPERATE

Fever, rapid pulse, leukocytosis, tender mass in the right upper quadrant, and muscle spasm are indications for such treatment as is consistent with the patient's condition One may for instance have to be content with a cholecystostomy as a life saving procedure Secondary cholecystectomy should be done as soon as the patient is ready—preferably during the same admission Advanced disease elsewhere may necessitate acceptance of cholecystostomy as the only surgical therapy possible

Upon the patient's admission relief of pain and rest are provided The state of hydration is determined by the hematocrit Appropriate fluid therapy is instituted, the colon is evacuated by rectal treatments, and distention of the stomach and small intestines is relieved by gastric lavage, gastric suction or Miller-Abbott tube deflation The latter may require twelve or more hours Repeated white blood counts are often valuable but may be confusing A flat abdominal film taken for calculi may or may not help It showed calculi in 42 per cent of the cases in this series

If the clinical course does not improve in twelve hours, either immediate surgical interference or more constant vigilance is indicated If the patient's condition has grown worse, operation becomes imperative If improvement does not continue after twenty-four hours, again surgery seems imperative Therein lie the diagnostic pitfalls and dangers of this disease, it is in this period that clinical signs may improve with the general treatment of the patient as a whole, yet the local gallbladder infection progresses to gangrene and perforation and these complications increase morbidity and mortality of operation done at any time in the course of the disease

If, on the other hand, improvement in signs, symptoms and laboratory data concur and are maintained, operation may be delayed *but* with the realization that complete resolution of the acute process often requires months, during which time the patient is subject to serious

complications and recurrent acute attacks which may force one to incomplete emergency surgery

In 1934 Touroff reported a microscopic study of gallbladders removed in seventy-five cases of acute cholecystitis in which symptoms and signs were either minimal or had entirely subsided. Of twenty-three cases with remaining minimal preoperative symptoms and signs nineteen (82.6 per cent) showed microscopic evidence of gangrene, perforation or empyema and four (17.4 per cent) showed only acute cholecystitis. Of the fifty-two cases without preoperative symptoms and signs, 55 per cent showed only acute cholecystitis microscopically and 45 per cent showed more advanced pathology, 68.4 per cent of the group with minimal symptoms and signs and 8.7 per cent of the group with no symptoms and signs showed microscopic evidence of progressive pathology. In the entire series 20 per cent of the lesions were considered to be progressive, while 80 per cent were considered to be subsiding or capable of subsidence.

What, then, should be the surgical approach to this disease? I believe that cholecystectomy is generally preferable to cholecystostomy, but that this attitude may be immediately modified upon exposure of the inflamed gallbladder. Such being the case, is it not justifiable in the group of cases upon whom one is forced to operate, to start with a local anesthetic and only a sufficient incision, usually *without* muscle division, for exploration? A small incision may limit exploration and cause pain, however, when necessary a stage of analgesia or even deep anesthesia may later be instituted and adequate exposure obtained.

When, under local anesthesia, an acute gallbladder is encountered surrounded by omentum with adjacent turbid fluid without odor, and a wall so tense and edematous as to render palpation from without useless for determining the nature of the contents of the viscus, the question arises: Should one proceed with removal or cease with drainage? The answer calls for mature surgical judgment which may mean the difference between a death, immediate recovery with subsequent secondary operation, and a cure. If the omentum is not removed from the gallbladder and if all stones can be removed, leaving a patent cystic duct, the subsidence of acute symptoms is often dramatic. If the omentum is not removed, however, an area of gangrene in the wall in the ampullary region, or an abscess between the wall and the omentum—possibly even into the liver—may be overlooked. Such additional pathologic change may or may not subside temporarily with drainage. When the omentum is removed and exploration or removal of the gall

bladder is performed, absorptive surfaces are so increased that a sharp toxic reaction may require strenuous supportive postoperative therapy which should be anticipated. Postoperative complications, particularly of the respiratory, vascular and renal systems, have occurred most frequently in this group.

I do not believe that a patient sick enough to warrant only a cholecystostomy should be subjected to a general anesthetic and a large incision without due recognition of the intrinsic dangers in each of these factors.

Within the first twelve hours of admission of a patient with severe pathologic involvement elsewhere, as an emergency procedure cholecystostomy may be preferable. Between twenty-four and forty-eight hours after admission, with the patient prepared and ready for operation, cholecystectomy becomes the operation of choice. After forty-eight hours, although cholecystectomy remains the preferred therapy, the electivity of cholecystostomy gradually increases in the presence of gangrene, empyema, perforation and pericholecystitis and the operation may become imperative when these complications are advanced.

As soon as a diagnosis of acute cholecystitis is made or suspected, the patient should be hospitalized and seen by a surgeon. Operations performed within the first twelve hours of onset are frequently done with a mistaken diagnosis. This complicates the surgical therapy with misplaced incisions and prolonged procedures which may preclude cholecystectomy.

If proper therapy is instituted and the patient does not respond immediate surgery is indicated. This situation requires evaluation by an experienced surgeon as to the extent of surgery indicated, anesthesia type and site of incision. Further judgment is necessary as regards operative procedure once the pathologic process is exposed. An inexperienced operator had best content himself with a life saving simple cholecystostomy. Unless the operator has adequate exposure, assistance and is able to provide effective postoperative therapy the risks of operative injury to important structures and postoperative complications are too great to be taken *lightly*.

If the observed patient responds to therapy and signs and symptoms subside, the surgeon who watches such a case should *realize* the statistical chances of complications he takes when the case is observed longer than twenty-four hours.

True it is that cholecystectomy in a properly prepared patient who

can tolerate that degree of surgery is the ideal surgical treatment of acute cholecystitis, but so many of these patients are in midlife or older, and have old age stigmata which become more pronounced following infection and operative trauma, that the therapy of the particular case should be individualized both as to the scope and type of surgery as well as the time it should be done

### CONCLUSIONS

1 Acute cholecystitis is a progressive disease in which complications of gangrene, perforation and abscess may occur in the presence of subsiding clinical symptoms, signs and laboratory data. These complications increase the mortality and morbidity of the disease and its surgical therapy.

2 In this series, the mortality and morbidity in acute cholecystitis were less when cholecystectomy was performed before the complications of the disease occur.

3 Cholecystectomy in the presence of the three main complications—gangrene, perforation and abscess—requires careful analysis of its indications in the *individual* case.

4 Cholecystectomy for acute cholecystitis is safer when the gall bladder is removed from the fundus down.

5 Cholecystostomy is not the operation of choice in acute cholecystitis unless local or systemic disease contraindicates removal of the viscus.

6 The best results from cholecystectomy for acute cholecystitis depend upon the active cooperation of the medical men who first see these cases.

Individual pathological, local and systemic responses to gallbladder infection in a group of middle age to elderly persons does not have such uniform pattern that a simple surgical therapeutic rule can be applied to the group. Treatment must be individually rationalized.

## SURGICAL EXPERIENCES WITH ULCERATIVE COLITIS

HENRY W. CAVE, M.D., F.A.C.S.\*

INTRACTABLE ulcerative colitis continues to respond successfully to surgical management. Medical treatment has proved inadequate when the process has reached the stage of irreversibility. Earlier diversion of the fecal stream when the disease is of the variety that will proceed to intractability should be employed more frequently. To differentiate the types of the disease in its incipency is difficult. All of us, internists and surgeons alike, are still too reluctant in advising early ileostomy. The clinician should be urged to acquaint himself with the proper use of the sigmoidoscope and the intelligent interpretation of roentgenographic findings.

It is important that careful preoperative medical observation be carried out. This includes a study of food allergy, evidence of avitaminosis, anemias, disturbances of mineral metabolism, as well as signs and symptoms of distorted physiology in other parts of the intestinal tract.

During the past eight years we have operated upon ninety-two individuals with eighteen deaths, an operative mortality rate of 19.5 per cent. Upon these ninety-two individuals one hundred and sixty-three operations have been performed. In the first two years of this work we did emergency operations upon fifteen individuals in the acute fulminating stage with eight deaths, a prohibitive mortality rate of 53 per cent. We soon learned that this type of case should not have a diversion of the fecal stream, when so debilitated by massive hemorrhages. We have in the elective group performed fifty ileostomies with four deaths, an operative mortality rate of 8 per cent. There have been forty-six subtotal colectomies with five deaths, an operative mortality of 10.8 per cent. There were nine partial colectomies with one death, an operative mortality rate of 11 per cent. Eight ileosigmoidostomies and eleven combined abdominoperineal resections were performed with no fatalities.

From these experiences we believe that we can formulate certain conclusions. The object of this paper is twofold: first, to discuss cer-

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tain impressions and secondly, to give in some detail technical suggestions and pitfalls

### SURGICAL INDICATIONS

The indication now for emergency surgery is impending perforation. Instances of massive hemorrhage are more successfully treated by the physician with transfusions and antispasmodics than by the surgeon, particularly in the acute phases. There are two distinct groups of patients who should come to surgery early: (1) those who have extensive pathological changes being continually handicapped by chronic symptoms of a variable severity, (2) those whose disease shows periods of activity and remissions, yet it is certain that the trend for them is downward. I should not fail to re-emphasize that in the future many of these individuals could be spared a prolonged illness and loss of the colon if ileostomy were performed at the earliest phase of the disease provided one is certain that this disease process is going to continue on and cannot be managed medically.

Another impression which has as yet not been statistically proved is that if this disease is so far advanced that the colon indisputably should be removed, then subtotal colectomy should be carried out sometime within six months following ileostomy. This statement is based upon the experience of several of these patients who are allowed to go for nearly a year and suddenly without apparent provocation a sudden violent flare up of the disease ensues with rapid loss of weight and shock. I am sure that one patient in our series was lost by not having her colon removed earlier. In me ileostomy is much more of a surgical risk than is subtotal colectomy. In sixty-five ileostomies there were twelve deaths, a mortality rate of 18 per cent. This of course, includes the eight deaths in the earlier massive hemorrhage group. Following diversion of the fecal stream there has been a uniform gain in weight. Of the sixty-five patients given ileostomy there was an average gain of weight in six months of 45½ pounds.

The most difficult task in this whole problem of the surgical treatment of ulcerative colitis is to teach each individual patient the proper care of his or her ileostomy. A detailed account of the care of ileostomy will be offered at a later date. Suffice it to say now that individual attention should be given these patients by the surgeon who operates upon them. They should be taught in the early postoperative period what to eat, what to drink, the type of bag to be used, the kind of protection for the surrounding skin which has proved of advantage

and they should be encouraged to quickly resume their normal activities.

A notable fact is that so many of these patients who have had ileostomy and subtotal colectomy have remained perfectly well without proctectomy. Only eleven of the whole group have undergone combined abdominoperineal resection. In one instance we have taken down the ileal stoma, replanting it into the rectum, and the patient has now been well for a year after operation. We still believe that the ideal plan of treatment for the patient with a lesion far advanced involving the entire colon and rectum is, first, an ileostomy, then subtotal colectomy, and finally, if the patient has not gained satisfactorily in weight and there is a bloody discharge from the anal opening, removal of the rectum.

#### TECHNICAL CONSIDERATIONS

**Ileostomy.**—Ileostomy is I believe more satisfactorily carried out through a McButney incision, curved well to the left with sufficient room between the site of ileal stoma and the right anterior-superior spine. The ileum in the majority of instances is divided approximately 6 inches from ileocecal valve (in only seven instances has the ileum been involved as far out as 10 inches from the ileocecal valve). A stab wound is made in the anterior abdominal wall 2 inches below the umbilicus and just to the left of the midline. The clamp is inserted through this opening and the ileum is grasped on the distal side with a Kocher clamp to the proximal side; the bowel is divided. The distal divided end is brought out through this stab wound and the mesentery of it is sutured to the peritoneum to prevent it from dropping back. The proximal divided end is brought out to the lower angle of the wound and great care is exercised in suturing the cut mesentery to the peritoneum of the undersurface of the anterior abdominal wall. Also, in order to prevent prolapse of the ileal stoma, No. 0000 plain catgut on a fine atraumatic needle is used to suture the circumference in various points of the ileum to the peritoneum as it is being closed. Interrupted fine chromic sutures close the muscular layers and fine steel wire is used in the skin. The ileum is brought out about 2 inches from the surface of the skin, is immediately opened and a soft catheter is inserted for immediate decompression purposes. These patients are encouraged to eat melba toast in the afternoon and a full breakfast the following morning. By actually feeding them early and putting them on a high protein and a high carbohydrate diet a minimal

of postoperative distention occurs, a sense of well-being is rapidly restored, and almost immediate functioning of the ileal stoma results. Needless to say, all of these patients are transfused at the time of ileostomy.

**Subtotal Colectomy**—The second stage procedure for the surgical cure of ulcerative colitis is subtotal colectomy. By that is meant the removal of the last 6 inches of the terminal ileum, cecum ascending transverse descending colon and most of the sigmoid down to approximately 6 inches from the peritoneal reflection. Forty eight hours prior to this operation a Miller-Abbot tube is inserted and this has been effective in telescoping the entire small bowel into a small mass. This was suggested to me three years ago by Dr Leland Mackarrick of Boston. This has reduced the operative time considerably because, when the right colon is being mobilized and resected, this mass of loops of small intestine is placed well over on the left side so that an adequate exposure is obtained. When the left colon is dissected from its bed and detached from its mesentery, and especially at the splenic flexure, the mass of small intestine is placed on the right side and here again adequate exposure is obtained.

Spinal anesthesia supplemented by intravenous sodium pentothal gives sufficient relaxation. The ileostomy stoma is sealed off with water proof adhesive. The left paramedian incision is a long one from the level of the xiphoid cartilage down to and including the previous mucous fistula of the distal divided ileum and on down 3 inches below this point. The last 6 inches of distal divided ileum is detached from the undersurface of the peritoneum and the cecal head is mobilized, all of this being done above the level of the terminal ileum which goes in to form the ileal stoma. The lateral parietal peritoneum is divided up on the right side and downward, so that the cecum, ascending colon and hepatic flexures are easily mobilized. The right colic artery is identified and ligated and great care is exercised in the identification of the third portion of the duodenum. This part of the duodenum is pushed upward and to the left, well out of the way of harm as one clamps the mesentery to the ascending colon. Formerly the greater omentum was dissected free from the transverse colon, but this was a tedious and time consuming procedure and we do not now believe it is necessary. The gastrocolic omentum and the mesentery to the transverse colon are divided between clamps.

The most difficult part of the procedure of subtotal colectomy in our opinion is the mobilization of the splenic flexure and the division

of the splenocolic ligament. Care is exercised in double ligating the middle colic artery. One fatality in our series resulted in faulty ligation of the middle mesentery artery. The vessel slipped back up into the mesentery and the patient died from a massive hemorrhage eight hours after operation. The splenic flexure and descending colon are mobilized after division of the parietal peritoneum, the left colic artery and its branches are ligated and divided. Usually at this stage we isolate and identify the left ureter so that injury to this structure is avoided.

After freely mobilizing the descending colon and the splenic flexure a decision is arrived at as to the level for division of the bowel. The bowel is pulled taut upward out of the pelvis and crushing clamps are applied, so that the protruding  $2\frac{1}{2}$  to 3 inches of the mucous fistula of the distal divided end is obtained. Certainly an attempt should be made to close in this distal divided end of the colon and drop it back into the peritoneal cavity. In one instance of our series a blow-out occurred with a resulting peritonitis and fatality. Sulfanilamide, 12 to 14 gm., is sprinkled in the right and left ureteral gutters, and the wound is closed. A transfusion is usually begun at about the time when the middle colic artery is divided.

It is surprising how little shock results from this procedure. The majority of the patients do better immediately after subtotal colectomy than they do after ileostomy. The Miller-Abbott tube is left in place for forty-eight to seventy-two hours following the operation in order to decompress the small intestine continuously.

**Removal of the Lower Sigmoid and Rectum**—As I have stated, in eleven instances have we removed the rectum. This was done because the patients still had an elevation of temperature or the bloody discharge from the anus was profuse, or they had a recurrence of other symptoms. We had hoped that by leaving in the rectum unless it was harmful that at some later date restoration of the fecal stream could be carried out.

Ninety per cent of all the cases of ulcerative colitis start in the rectum. In 10 per cent the lesion is restricted to the right colon and in these instances preliminary end to side ileosigmoidostomy is satisfactory, with later removal of the colon down to the point of anastomosis. We have carried out this procedure in eight instances.

There have been nine patients in whom the disease has been limited to the rectum, sigmoid and descending colon. The diseased bowel was removed in two stages, the first stage consisting of transverse colos-

tomy with resection of the descending colon and the second of removal of the lower sigmoid and rectum.

A meticulous suturing of the lower divided sigmoid to the peritoneum and anterior wall should be carried out. In one instance intestinal obstruction resulted caused by a loop of small bowel pushing its way out through a too loosely sutured distal divided end.

#### SUMMARY

Intractable ulcerative colitis is a surgical disease. The operation is performed in three stages: (1) ileostomy, (2) subtotal colectomy, (3) removal of the lower sigmoid and rectum.

Ninety-two individuals have been operated upon with an operative mortality of 19.5 per cent. This includes eight deaths in fifteen individuals who were operated upon in the acute fulminating phase of the disease; these are now listed as elective rather than emergency operations. Subtotal colectomy should be performed within six months after ileostomy. There has been a remarkable gain in weight in all of those patients who survived ileostomy. Minute instructions should be given all patients in regard to their ileal stoma.

In the 10 per cent of patients in whom the disease is limited to the right colon, end to side ileosigmoidostomy with subsequent resection of the diseased segment has proved eminently satisfactory.

Unless a patient discharges blood from his rectum following ileostomy and subtotal colectomy and he as an individual remains in good condition, the rectum should not be removed. There is ever the possibility that the ileal stoma might be taken down and reimplanted into the rectum in order to reestablish the fecal stream.

Earlier ileostomy in this whole group of individuals with the intractable variety of the disease will reduce the morbidity and mortality.

# RENAL LITHIASIS AND ITS TREATMENT

A HAYAN, MD, FACS\*

ONE of the most intriguing and at the same time one of the major problems in urology is undoubtedly that of nephrolithiasis.

In reviewing the admissions to the Urological Service at Mount Sinai Hospital for the past ten years, one is impressed by the high incidence of calculous disease. Nephrolithiasis presents many interesting problems from etiologic, medical and surgical aspects. Through our Follow-up Clinic, which has been functioning now for almost twenty years we have followed the course of thousands of cases of nephrolithiasis—many from their incipency to the final stages in which the patients have succumbed to the disease. No patient with calculosis is discharged from the clinic as "well" until he has had at least a five-year check-up. If recurrences are noted, he is kept under observation indefinitely.

More and more are we impressed by the seriousness of urinary lithiasis. In many patients, especially those with bilateral involvement and multiple recurrences, the disease is a malignant process, often uninfluenced by any type of medical or surgical treatment. The sequence of calculous obstruction and infection too often produces serious symptoms and complications, eventually ending in irreparable damage and destruction of renal tissue. Far too many patients end up with a nephrectomy, the result of neglect, errors in diagnoses, symptomless stones, or poor management of their condition from start to finish.

## ETIOLOGY

A voluminous literature has appeared in recent years on this subject alone. Any number of theories and hypotheses have been advanced, many to be discarded in the light of further experiences. The scope of this paper does not admit of a comprehensive review of this extensive literature, but a few of the more recent outstanding conceptions that have thrown new light on the subject will be discussed.

Calculous disease as a result of *vitamin A deficiency* has received considerable attention from numerous investigators. It has been pos-

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tomy with resection of the descending colon and the second of removal of the lower sigmoid and rectum.

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ONE of the most intriguing and at the same time one of the major problems in urology is undoubtedly that of nephrolithiasis.

In reviewing the admissions to the Urological Service at Mount Sinai Hospital for the past ten years, one is impressed by the high incidence of calculous disease. Nephrolithiasis presents many interesting problems from etiologic, medical and surgical aspects. Through our Follow-up Clinic, which has been functioning now for almost twenty years, we have followed the course of thousands of cases of nephrolithiasis—many from their incipency to the final stages in which the patients have succumbed to the disease. No patient with calculosis is discharged from the clinic as 'well' until he has had at least a five-year check-up. If recurrences are noted, he is kept under observation indefinitely.

More and more are we impressed by the seriousness of urinary lithiasis. In many patients, especially those with bilateral involvement and multiple recurrences, the disease is a malignant process, often uninfluenced by any type of medical or surgical treatment. The sequence of calculous obstruction and infection too often produces serious symptoms and complications, eventually ending in irreparable damage and destruction of renal tissue. Far too many patients end up with a nephrectomy, the result of neglect, errors in diagnoses, symptomless stones, or poor management of their condition from start to finish.

### ETIOLOGY

A voluminous literature has appeared in recent years on this subject alone. Any number of theories and hypotheses have been advanced, many to be discarded in the light of further experiences. The scope of this paper does not admit of a comprehensive review of this extensive literature, but a few of the more recent outstanding conceptions that have thrown new light on the subject will be discussed.

Calculous disease as a result of *vitamin A* deficiency has received considerable attention from numerous investigators. It has been pos-

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sible to produce renal and vesical calculi composed of phosphates and carbonates, in the experimental animal, with consistent regularity by placing them on vitamin A deficiency diets. Various factors may be involved in the production of these calculi. Most of the animals developed urinary tract infections, and pyelitis and cystitis were frequently observed at autopsy. After two and one half to three months, keratinization of the epithelium of the urinary tract occurred. It was believed that the resultant desquamation of the epithelial cells served as a foreign body, and formed the nucleus of a stone. It was also thought that the long persistent alkalinuria present causes an increase of the crystalloids to a point where the protective action of the colloids have disappeared. In clinical lithiasis there is as yet no definite proof that vitamin A deficiency is a frequent etiologic factor. In fact recently Jewett, Sloan and Strong,<sup>1</sup> examining a group of ninety eight cases of urinary lithiasis by photometric tests, vitamin A blood content studies and autopsy examinations of the respiratory and urinary tracts for epithelial metaplasia came to the conclusion that as yet there is no proof that vitamin A deficiency is an etiologic factor in urolithiasis in man. All in all, one may state that the occurrence of clinical and renal lithiasis as a complication of nutritional deficiencies has not been substantiated despite the conclusive results obtained in animal experimentation.

Randal<sup>2</sup> advanced the hypothesis that in primary calculus formation, the initiating factor is a *microscopic lesion of the renal papilla* consisting of mucosal and submucosal necrosis with ulceration on which urinary salts are deposited. Further precipitation of urinary salts increases the growth of the stone, which eventually may become broken off or lie free in the pelvis or calices. Recent investigators although confirming the presence of calcium salts in the papillae, were unable to prove that they contributed towards the coexisting calculus and could only regard the lesion as a *focus minoris* in the development of calculus.

In 1934, Barney and Mintz,<sup>3</sup> and Albright<sup>4</sup> and other investigators called attention to the *relationship between hyperparathyroidism and urinary lithiasis*. Hyperparathyroidism mobilizes calcium and phosphorus, and causes a rather characteristic bony depletion. In this condition the blood calcium level is elevated above the normal of 11 mg per 100 cc, and the phosphorus level is below the normal of 3.5 mg per 100 cc. The calculous disease associated with this condition is often bilateral, or there may be a condition in which calcium deposits

are scattered through the renal parenchyma—so called calcinosis. In our material, although repeated blood studies have been made, our findings are in accord with those of the Mayo Clinic, where hyperparathyroidism was regarded as an etiologic factor in less than 0.2 per cent of the cases. It would seem that, in the Boston clinics, a much higher incidence of the association of urinary calculus and hyperparathyroidism has been noted. Sixty-seven patients with hyperparathyroidism were operated on at the Massachusetts General Hospital in a period of ten years. The majority of these patients had renal calculi with no demonstrable disease of the bones. Albright and Cope<sup>3</sup> report that approximately 15 per cent of patients with renal calculus have hyperparathyroidism as the cause of their stones. They stress the fact that in only a few of the cases is the disease sufficiently marked to diagnose it by bone changes, or by one blood examination. A number of blood determinations should be made, and the patient is often observed for a long period of time before the diagnosis is finally established. Of interest is the fact that no further recurrences of stone took place where the metabolism was corrected by surgery.

The above represents the newer etiologic concepts, there are many number of other factors held responsible for calculus formation. Disturbances in calcium metabolism, especially in bedridden patients, is sometimes held responsible. Many of these patients show a high calcium excretion without evidences of hyperparathyroidism, and without any changes in the blood calcium or phosphorus. Stasis and infection play an important role, in the presence of a urea splitting organism (such as the *Bacillus proteus*), the recurrence rate of calculus is especially high. Disturbance in amino acid metabolism is no doubt responsible for the formation of cystine and xanthine calculi. Cystine calculous disease is not infrequently a familial disease.

A number of years ago the colloid-crystalloid mechanism of stone formation was stressed. Other factors also to be considered from an etiologic viewpoint are age, diet, climate and heredity.

In general, renal calculi may be classified as a primary or secondary. The primary calculi, such as calcium oxalate and phosphate, ammonium urate, uric acid, cystine and xanthine are usually deposited in urines of a variable range of acidity. The secondary calculi, such as calcium carbonate, calcium phosphate and ammonium magnesium phosphate, are found in alkaline urines. In 1928 I reported<sup>6</sup> a series of unusual calculi composed of albumin and fibrin. In recent years many cases of sulfanamide concretions have been reported; most of them

relieved by medical measures but others requiring surgical intervention

### CLINICAL ASPECTS

The symptomatology of renal lithiasis may be very protean, varying from a practically symptomless state to violent acute manifestations. The symptoms naturally will depend on the size, number, location of the calculi, whether or not infection is present and factor of obstruction. Calculi may remain quiescent for long periods of time causing but minor symptoms—this is especially so of calc stones. Such a calculus may then be suddenly extruded into the pelvis and cause obstructive symptoms with resultant acute manifestations. The symptoms most frequently associated with stones are *pain* of varying character, *pyuria* and *hematuria*. These symptoms are often absent or mild in character and as a result calculi are often overlooked for long periods of time. Renal calculi often produce symptoms referable to the gastrointestinal tract—the so called *silent stones* are no means infrequent in our experience and they generally have been stones of large size. Asymptomatic calculi are not infrequently discovered in the course of a routine investigation. The presence of blood cells and pyuria warrant a complete urological study. Because symptoms typical of renal calculus are so often missing or may be mild, many patients have been subjected to unnecessary appendicectomy and gallbladder operations or even explored for a supposed intestinal obstruction which was due to a reflex ileus.

*Bilateral* renal calculi warrants especial emphasis both from clinical and surgical viewpoints. In a series of 477 cases of renal lithiasis reported from our Clinic over a six year period, bilaterality was present in 110 cases or 26 per cent of the patients—a rather high incidence. According to Oppenheimer<sup>2</sup> who published this paper, a patient is considered to have bilateral disease when calculi are known to have occurred on either side at any time as judged by the history, hospital studies, follow up and observation. Of interest in this study was the fact brought out that many cases thought to be unilateral when first studied subsequently showed involvement of the other kidney at a later date.

Of 130 patients given the diagnosis of unilateral lithiasis and operated upon who were followed for a period of from one to seven years, nineteen patients or 14.6 per cent later presented evidences of calculous disease in the opposite kidney.

Bilateral renal lithiasis is a very serious condition, often progressive, and uncontrolled by any type of treatment. Surgery is often useless except to relieve an acute condition, for some patients are stone formers whose metabolism in the light of present day knowledge cannot be influenced. Recurrence follows on recurrence—first one kidney is involved, then its mate undergoes a similar process. These cases are practically always complicated by obstruction, stasis and infection with gram-negative organisms—especially of the enterococcus and proteus type. These patients are resistant to dietary regulations and chemotherapy. Ultimately there is so much kidney destruction that death ensues from renal insufficiency. Of interest is the fact that occasionally recurrences will show variations in the chemistry of the stone.

#### UROLOGICAL INVESTIGATION

A complete urological investigation entails a careful urinalysis, radiography (Figs 189–194, 196–198, 200, 201), pycnography (Figs



Fig 189—Typical calcium oxalate calculus

195, 199) and cystoscopy. Approximately 10 to 15 per cent of renal calculi fail to visualize in plain films. Uratic and uric acid stones either do not cast a shadow, or if so, visualize faintly (Fig. 201). For more



Fig 190



Fig 191

Fig 190 - Unilateral dendritic calculus

Fig 191 Bilateral nephrolithiasis



Fig 192



Fig 193

Fig 192 Multiple faceted renal calculi (nephrectomy)

Fig 193 Bilateral nephrolithiasis (calcinosis) Calculi embedded throughout parenchyma

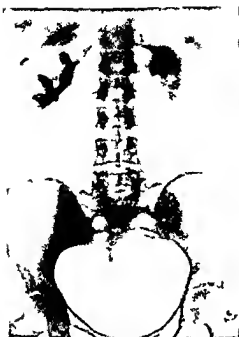


Fig 194

Fig 194—Bilateral renal calculi



Fig 195

Fig 195—Pyelogram of bilateral renal calculi



Fig 196

Fig 196—Bilateral staghorn cystic calculi



Fig 197

Fig 197—Bilateral renal calculi



Fig 198



Fig 199

Fig 198—Calculus in upper calyx

Fig 199—Pyelogram of calculus in upper calyx demonstrating a pyocalyx



Fig 200



Fig 201

Fig 200—Calculus in pelvis of kidney with faceted stones in calyces

Fig 201—Uric acid calculus in pelvis Pyelogram showing filling defect

complete information intravenous urography is essential or if not available cystoscopy and ureteral catheterization combined with

pyelography. We can frequently make a diagnosis of the type of stone by finding crystals in the urine—this is especially important in the case of cystine stones. Bilateral ureteral catheterization combined with functional tests, separate urines for culture, and pH determinations, complete the investigation.

#### MEDICAL TREATMENT AND ITS INDICATIONS

After a complete urological investigation, we are then in a position to determine whether the treatment should be medical or surgical. Surgery may be contraindicated in certain cases of bilateral staghorn calculus, recurrences, following surgery, and cystine stones.

**Diet, Particularly High Acid Ash and High Vitamin Intake**—From time to time reports have appeared in the literature on the dissolution of calculi by dietary regulations or by means of dissolving solutions introduced retrograde. Whereas in laboratory animals successful results have been obtained by Higgins<sup>4</sup> and others with acid ash diets and high vitamin A and D intake, the clinical application has been most disappointing, with the exception of cystine calculus which has been dissolved by a high alkaline ash diet reinforced by sodium bicarbonate. In view of the fact that a diagnosis of cystine calculus can be made by finding the crystals in the urine, this type of calculus should be given the benefit of trial of the high acid ash and vitamin diet over a period of from ten to twelve months, provided the stone does not cause obstruction and infection.

Following the preliminary successful reports of Higgins on the dissolution of renal calculi in the human being, we established a special nutritional clinic at Mount Sinai Hospital under the control of the Urological and Medical Services. A series of carefully controlled cases treated by the methods then advocated were studied. Fifty-two patients in all were treated for varying periods of time. These studies by Oppenheimer and Pollack<sup>5</sup> may be summarized as follows. Twenty-seven patients were on the diet for from six to sixteen months, an average duration of eleven months. Twenty of these patients maintained a mean bladder pH of 5.2 or under. In none was a complete or partial solution (disappearance) of the urinary calculus noted on the frequently controlled x-ray films. Five patients showed an increase in the size of their renal calculi, and in one patient a new stone formed while on the regimen. In our hands, the high vitamin and ash diet has not caused a disappearance or reduction in size of renal calculi of the alkaline earth type.



**Solution of Calculi by Means of Solution G**—In 1939 Albright, Sulkewitch and Chute<sup>10</sup> introduced the sodium citrate acid solution at a pH of 4 for the dissolution of phosphatic calculi. Clinical application demonstrated this solution was too irritating to be of practical use. In 1942, Suby<sup>11</sup> and Albright published their results with Solution G. They found that the addition of magnesium to the sodium citrate citric acid solution rendered the solution less irritable. In their latest communication,<sup>1</sup> six selected cases of renal lithiasis were reported in which the solution was used successfully for the complete or partial dissolution of calcium phosphate calculi. The method is painstaking and requires meticulous care, but in certain selected cases, especially recurrences, it should be given a trial. Our personal experience with this method has been limited to three cases of renal lithiasis and the results were unsatisfactory. The treatment had to be discontinued because of attacks of acute pyelonephritis precipitated by the introduction of the solution. One patient with multiple recurrences was treated through a nephrostomy tube, the other two cases through ureteral catheters. I feel that at the present time such treatment should be confined to patients with residual or recurrent calculi where there is a nephrostomy tube in situ.

### SURGICAL TREATMENT

**Indications for Surgery**—Surgical intervention is indicated, first, from the subjective point of view, if the calculus produces attacks of pain or colic, and is of such a size that its spontaneous passage is questionable. Any calculus that causes infection and obstruction should definitely be removed. The question arises whether a silent calculus, which is practically symptomless, should be removed surgically. I think the consensus is in favor of surgery, for if left undisturbed, most calculi sooner or later cause obstruction or infection and should be considered as a potential cause of trouble.

In recent years there has been considerable discussion as to whether or not *staghorn calculus* (Fig. 196) should be subjected to surgery. This type of calculus may be present for years practically symptomless but causing gradual destruction of the parenchyma. Unless the condition has progressed so far as to cause marked kidney destruction and chronic pyelonephritic changes we feel that in many instances surgery offers the patient a better chance of preserving his kidneys than a policy of watchful waiting.

In *recurrent renal lithiasis*, the above indications do not always hold true, and one must be more conservative before subjecting a patient to a secondary procedure.

The surgical treatment of renal lithiasis often taxes the skill and ingenuity of the surgeon, especially in cases with multiple calculi and bilateral renal lithiasis. What I wish to emphasize at this time is that whenever possible conservatism in renal surgery cannot be stressed too strongly. We should not lose sight of the fact that, though the opposite kidney may be free of calculus at the time of operation, in later years its mate may undergo a similar fate.

**Solitary Calculus in the Renal Pelvis**—Operation for the solitary calculus in the renal pelvis is probably the simplest procedure of all for stone, except where there is a small intrarenal pelvis. Under such circumstances, it may be necessary to do a nephrotomy. Calculus in the pelvis may generally be removed through a posterior pyelotomy incision. Care must be taken, if the stone is a soft one, not to break it, for some of the fragments may elude us and become the nidus for recurrence. If the pelvis is of fair size and extrarenal in type, the incision in the pelvis may offer sufficient room for palpation of the calices, occasionally a smaller calculus (not visualized in the x-ray films) may be present. At times in a small pelvis, additional space may be obtained by retracting the parenchyma at the hilus upwards with a blunt retractor. If the stone cannot be removed through the posterior wall of the pelvis, a better approach may be obtained through either an anterior or an inferior pyelotomy incision.

After the extraction of the calculus, the kidney is thoroughly lavaged (preferably with a syringe of the Gibson type) through which suction can be applied so as to remove small blood clots, debris or fragments of stone which may have been chipped off. Unless the pelvic wall is inflamed or friable, or infection is present, the incision is closed with No. 000 plain catgut sutures, and the lumbar incision closed with a Penrose drain.

**Multiple Pelvic and Caliceal Stones (Fig. 192)**—These present a more difficult problem, especially if the stones are small. A roentgenogram should be taken immediately prior to operation so as to be certain a calculus has not migrated into the ureter, or been extruded from the pelvis into a calix, or vice versa. Facilities should be on hand to take x-rays of the surgically exposed kidney. During the process of mobilizing the kidney, a calculus may be dislodged into the ureter, so it is our routine to first expose the upper ureter and occlude it temporarily.

by a loop ligature. Before this method was routinely employed we occasionally had the unpleasant experience of having postoperative obstructive symptoms arise due to the passage of an unrecognized stone into the ureter.

After the pelvis has been opened the calculi should be removed with forceps and the calices explored digitally. The pelvis and calices are then lavaged with a Gibson syringe. At times a small calculus in a calix cannot be dislodged from its position either with forceps or suction. The best procedure then is to fix the calculus with a finger

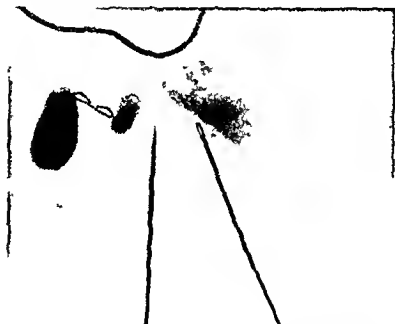


Fig. 707—Dental film of exposed kidney on operating table demonstrating three residual calculi.

in the calix and extract it through a small nephrotomy incision. After comparing the x-ray films with the calculi removed residual calculi may be located by needling. An x-ray control on the table should then be taken as a routine procedure.

*Roentgenography of the Surgically Exposed Kidney*—At this point I consider it advisable to discuss the question of roentgenography of the surgically exposed kidney as it will be referred to later when the question of staghorn calculus and stone recurrences is considered. X-ray control with films has supplanted fluoroscopic control which

we found unsatisfactory. We have been using this method since 1928; the only improvement in technic since then has been substituting a simple type of dental film for the cassette previously employed (Figs. 202, 203). In 1940 the results of this procedure, as employed on our service, was reported by Dr. Oppenheimer.<sup>13</sup> His conclusions were that operative x-ray control is a valuable aid in the operative treatment of renal calculus, and its more extended use is advocated. In a series of eighty-five operative x-ray control examinations, stones or stone fragments which could not be palpated or found with the roentgenogram, were located by means of this procedure in twenty-nine cases, or 34 per cent. The procedure of course is not without certain draw-



Fig. 203.—Second film showing one residual calculus.

backs. Occasionally calculi seen on the films could not be located. Its extended use would, however, lower our percentage of so-called true recurrences, for undoubtedly many of the recurrences are residual calculi left over at operation.

**Caliceal Calculi.**—In general, primary caliceal calculi (Figs. 198, 199) seldom cause symptoms and can be safely watched. At any time, however, such a calculus may be extruded into the pelvis or upper ureter, and cause acute obstructive symptoms. Occasionally, a caliceal stone with infection may cause a stricture of the infundibulum and produce a pyocalix. In this type of case, even after removing the calculus, stasis and infection may persist, and can only be eradicated by a

*calicectomy* of the upper or lower calix. This operation has found more advocates in recent years, and we have been pleased with our results in a number of cases. We have never seen a permanent urinary fistula develop after this procedure. The operation is a rather radical one, and only indicated in a selected group of cases. A wedge shaped incision is employed, excising the upper or lower pole of the kidney with the calix, and approximating the cut ends with fat reinforced sutures for hemostasis. It is not necessary to supplement this with a nephrostomy, instead, a small pylotomy incision is made which acts as a safety valve for the passage of small clots which may form.

**Unilateral and Bilateral Renal Calculi**—The guiding principle in the management of unilateral renal calculi (Fig. 190) should be conservatism, and nephrectomy should be performed only as a last resort. We should always bear in mind the wonderful reparative power of the kidney. Time after time we have observed kidneys almost devoid of function recover to a remarkable degree after the calculus has been removed and free drainage established. In evaluating the various tests to determine kidney function, one should bear in mind that non-visualization of a kidney by means of intravenous urography does not necessarily imply a functionless kidney. The element of obstruction plays an important role in inhibiting kidney function, and once the obstructive element is removed, the kidney may slowly regain its function. By a careful study of the x-ray films, one can often determine how much of the parenchyma has been destroyed. Another reason for extreme conservatism is the irrevocability of nephrectomy with subsequent danger to the patient should calculus involvement of the remaining kidney ensue. In a series of 130 patients operated upon on our service for unilateral calculous disease, calculus formation in the opposite kidney subsequently occurred in 14 per cent. The final decision as to the type of surgery will be determined by the examination of the exposed kidney on the operating table.

In recent years there has been considerable discussion as to whether or not to operate in cases of large dendritic calculi. The pendulum has swung from extreme conservatism, which implied nonoperative treatment, to present day trends favoring more radical surgery. It is true that staghorn calculus may often remain symptomless for years with but very slow destruction of the kidney. Generally there is progressive gradual destruction of the parenchyma, eventually with infection supervening. There is a type of multiple unilateral or bilateral calculus formation which should not be subjected to surgery, in this condition

the kidney parenchyma is infiltrated with calculi of varying sizes—a form known as *cricomosis* (Fig 193). There is too much kidney destruction involved in trying to remove the numerous stones.

In operating for *bilateral renal calculus* (Figs 191, 193–197), the better of the two kidneys should be operated on first, although there are other factors which may influence us otherwise. We must consider the size and location of the stone, and whether or not infection or obstruction is present. Pain, hematuria and pyelonephritis play an important role; the kidney responsible for these symptoms should be given prior consideration. Whenever possible the calculus causing obstruction should be removed first. Bilateral simultaneous operations for dendritic calculi should never be performed. We may be faced with difficult problems in bilateral lithiases, especially when complicated with a ureter calculus. Under such circumstances it may be advisable to remove a renal calculus, and a calculus in the opposite ureter at the same time. Any number of combinations of renal and ureteral lithiases and pathology may be present at the same time, such as a calculous pyonephrosis on one side with multiple renal calculi in the opposite kidney, or a perinephric abscess may be present, greatly complicating the picture. Then again, calculi may be present in a horseshoe kidney, and in various other types of congenital renal anomalies.

Recently there have been a number of references to the incision advocated by Prather<sup>14</sup> for the removal of *staghorn calculus*. He advocates a V-shaped nephrostomy incision on the posterior surface of the kidney with the apex in the kidney pelvis, claiming for it a minimum of kidney destruction. We have employed the standard nephrotomy incision in the so-called bloodless line, and have not hesitated to incise the kidney from the upper to the lower pole. This type of surgery requires a bloodless field so that visualization is perfect.

After the kidney is fully mobilized a Doyen right angle clamp with rubber tubing on the blades is placed on the pedicle. A tape ligature is then placed around the ureter just below the pelvis to prevent fragments from entering the ureter. The size of the nephrotomy incision will depend on the size of the calculus. The stone with its branches in the calices is then removed—if possible, in toto, if not, in as few fragments as possible. The main difficulty is freeing the branches from the calices in which they are often firmly embedded. It may be necessary to incise the calices to extract the stone. It is in the major and minor calices that fragments are most apt to be left behind. The clamp should be released every five minutes for a few seconds to allow the

blood to circulate. Using this technic I have left the clamp on as long as thirty minutes and as far as I can recall have seen no untoward effects.

The calculus is now compared with the x ray films after which the kidney is thoroughly lavaged. Control x rays are taken using as a guide for localization of unrecognized fragments three straight needles threaded with long pieces of silk so that they cannot possibly be lost. The needles are placed in the upper and lower poles and one in the center of the kidney. Occasionally it may be necessary to take two x ray controls before a fragment can be located. The kidney is now sutured with fat reinforced No. 1 chromic sutures or ribbon catgut is employed. If there is infection or a hydronephrosis is present a small lower pole nephrostomy is done. If not I dispense with a nephrostomy and make a small incision into the pelvis or ureter so that clots can readily be extruded. An extensive nephrotomy may prove to be a procedure attended by considerable shock. Routinely, these patients should be transfused on the operating table. Occasionally if a pyocalyx is present it may be advisable to combine this operation with a calicectomy.

For the removal of *multiple small renal calculi*, a new technic has recently been described by Dees and Fox.<sup>1</sup> The procedure consists of the injection of a coagulable substance into the renal pelvis when the kidney is exposed. The clot which forms from the human fibrinogen and globulin employed fills the pelvis and calices, enmeshes all the calculi and is then removed through a pyelotomy incision about five minutes after injection.

**Recurrent Renal Lithiasis.**—The problem here is often a very difficult one. The kidney is usually found markedly adherent so much so that it cannot be mobilized. A nephrotomy under such circumstances is a more formidable procedure.

The incidence of recurrence of renal lithiasis after conservative surgery will depend on many factors: the chemistry of the stone, infection, the type of operation performed and the duration of follow up observations. A questionnaire follow up will not show as high a percentage of recurrences as when the patient is examined by x rays, cystoscopy and pyelography. We must differentiate between true and pseudo recurrences. Now that x rays are taken routinely either on the operating table or before the patient is discharged from the hospital we can readily differentiate between the two. In a series of four hundred and twenty two cases of renal calculus reported

from our clinic by Oppenheimer<sup>14</sup> in 1939, 85 per cent of the operated cases were followed in average of four years. One hundred and forty one of these patients had conservative renal surgery. The true recurrence rates in all types of cases were for pyelolithotomy 14.9 per cent, pyelonephrolithotomy 32 per cent, and nephrolithotomy 29.4 per cent, while the total rates of the true recurrences plus the residual recurrences were 24 per cent, 54 per cent, and 58 per cent respectively. In unilateral cases the true recurrence rates were 13 per cent, 23.5 per cent, and 23.1 per cent respectively. The true recurrence rate for all conservative operations in the primary stone cases (calcium oxalate, or calcium oxalate and calcium phosphate) was 8.1 per cent, while for the secondary stone cases (mixed calculi) it was 28.3 per cent.

**Urolithiasis Medicamentosa**—In recent years with the advent and widespread use of sulfonamides, more and more renal complications have been observed. Occasionally a urolith will form requiring surgery. The proper prophylactic treatment, when large doses of the sulfa drugs are being administered, should reduce these complications to a minimum. The urine should be checked frequently for blood, albumin and crystals, the daily intake and output carefully checked, and the urine kept alkalinized with a large fluid intake. The blood level is no indication of the degree of precipitation. The precipitation of acetyl sulfa crystals in the urine takes place in the tubules, if there is not a sufficient fluid intake, the urine becomes concentrated, agglutinates, and may form a calculus requiring surgery. The crystals may produce anuria by blocking the tubules or ureter. Alkalinization, high fluid intake, and ureteral lavages will generally take care of the situation although any number of fatal cases have been reported.

**Postoperative Treatment of Renal Lithiasis**—Surgery is just one phase in the treatment of patients with renal lithiasis. We should endeavor to eradicate infection and eliminate the factor of stasis, focal infections should be cleared up, and a proper dietary regimen instituted. Urinary infection cannot be controlled unless stasis has been eliminated. We now have available to combat infection the sulfa compounds, mandelic acid and penicillin.

We should of course determine, whenever possible, the chemistry of the stone. If a calculus cannot be obtained, an examination of the urinary crystals and pH determinations will be of aid in arranging the dietary treatment. For uric acid, cystine, and xanthine calculi an alkaline ash diet is prescribed. Oxalate calculi are at all times difficult to control, all foods containing a high oxalate diet should be prohibited.



Phosphate and carbonate calculi require an acid-ash diet, and the maintenance of the pH of the urine around 5.2. Vitamin A should be given in large doses—50,000 units daily. Of great importance is a large fluid intake. Patients confined to bed with fractures, or bone disease, should be placed on a high vitamin A and acid-ash diet, fluids should be forced and active and passive motion of the limbs not involved should be practiced. Patients should be x-rayed every three to six months over a period of several years, and have intravenous urograms taken occasionally. There is no question that a rigid adherence to these precepts will be of great value in reducing the recurrence of renal lithiasis.

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## PHLEBOTHROMBOSIS OF THE FEMORAL AND ILIAC VEINS

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Two conditions of the veins of the extremities which occur post operatively are fraught with danger for the patient. Alton Ochsner has given the following names to these two conditions: (1) thrombophlebitis and (2) phlebothrombosis.

1 *Thrombophlebitis* is primarily an infection of the vein wall associated with elevation of temperature, swelling of the leg and redness over the course of the vein. There is usually a marked periphlebitis. According to the figures of the Toronto Clinic, only 10 per cent of these patients throw off emboli. Because the patient is ill, because the temperature is usually high, and because there is a good deal of pain, the condition is generally recognized by the surgeon, and appropriate measures, such as rest and elevation of the part, are applied.

2 *Phlebothrombosis* means, in general, that the thrombus in the vein is much more prominent than the inflammatory process. It is frequently unrecognized and it is this lesion that I wish particularly to discuss. During the past three years I have had an opportunity to operate upon thirteen patients in whom phlebothrombosis of the femoral and iliac veins had occurred. Of these thirteen, nine had "shot" between one to eight pulmonary emboli, while four had had no evidence of embolic formation. As there is often only slight or no swelling of the leg and a minimum elevation of temperature, phlebothrombosis of the deep veins of the calf may be overlooked. Embolism may be the first warning that thrombosis has occurred.

Homans has shown experimentally that ligation of the femoral vein and its branches will not cause swelling of the leg, but if the lymphatics as they pass under Poupart's ligament are destroyed, the typical swollen leg appears. As this process is not primarily inflammatory, the evidence of swelling is much less marked than in thrombophlebitis. Therapy is directed toward preventing pulmonary embolism.

In this series although four patients had not shown evidence of embolism, they were operated upon in order to be certain that embolism would be prevented.

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## DIAGNOSIS OF PHLEBOTHROMBOSIS

In these days of shortage in nurses and physicians, phlebothrombosis of the veins of the leg may develop and not be recognized until embolism has occurred. Obviously dehydration and venostasis are more apt to occur where nurses are not present to administer fluids and to move the patient. As a result, in many hospitals throughout the country the early mobilization of the patient has been started. In many clinics the patient dangles the feet over the edge of the bed on the first postoperative day and is gotten out of bed the second postoperative day. Thereafter he is rapidly encouraged to walk. This procedure has cut down the incidence of thrombosis and embolism in the clinics where it has been adopted.

With the deficiency in nurses the four-hour temperature chart is often omitted so that the attending surgeon does not recognize that there is a moderate elevation of temperature for a longer period of time than what normally would be present. The busy surgeon often does not have the time to ask the patient about minor complaints. He does not strip the bedclothes down and palpate the legs of a patient who has a slight elevation of temperature and is not running a normal postoperative course. Where phlebothrombosis of the deep veins of the calf has occurred, the Homans' sign is a valuable diagnostic aid.

**Homans' Sign**—If the foot is dorsally flexed, pain is noted by the patient in the calf. This is due to compression of the vein by the extension of the muscles of the calf. If both legs are semiflexed, with the patient lying on the back and the feet resting on the bed with the knees in a semiflexed position and the calves carefully palpated by compressing the gastrocnemius muscle against the posterior surface of the tibia, pain will be elicited on the affected side and there is a sensation of deep edema. Usually the affected calf will be 1 to 2 inches larger in circumference, but this may not be true. Pressure in the popliteal space will elicit pain on the affected side.

If the thrombus has extended upward along Hunter's canal to reach the iliac veins, palpation at Poupart's ligament will reveal a slightly tender, pencil-like mass in close proximity to the femoral artery.

While venograms are used in many clinics as a diagnostic aid, it has been my experience in general that the diagnosis can be made clinically, and usually as accurately as by venography.

## SURGICAL PROCEDURES

There are two surgical procedures for phlebothrombosis of the superficial and deep veins of the lower extremity, namely (1) *Proximal ligation* As the name indicates, the vein is ligated during the early course of the disease—when it is possible—to expose the vein above the clot. (2) *Thrombectomy* I am particularly referring to the use of thrombectomy in the type of phlebothrombosis in which on exposure the clot in the femoral vein extends upward beyond Poupart's ligament into the iliac vein, often as far as the bifurcation of the vena cava

In this paper I will describe solely the second procedure because I think that all surgeons are agreed that proximal ligation entails very little risk and allows immediate mobilization of the patient. There are many, however, who dispute the advantage of evacuating a clot when it extends above Poupart's ligament.

*Thrombectomy—Anesthesia*—Many of these patients have had so much lung involvement that they must be placed in a semisitting position for operation. In this position they cannot safely be given inhalation anesthesia, and spinal anesthesia is also risky because, in order to flex the thighs properly to insert the spinal needle, it is possible that a clot may be dislodged. Therefore, in my series I have used local anesthesia in cases with serious lung involvement, in others, cyclopropane.

One objection to local anesthesia is the difficulty of eliminating pain at the time the femoral vein is isolated and dissected free from the femoral artery. Within the sheath of the artery there is usually an inflammatory reaction and there are gelatinous adhesions of artery to vein. Dissection is difficult and infiltration dangerous.

*Surgical Technique*—An incision is made over the course of the femoral artery as it presents below Poupart's ligament. The vein is isolated and dissected free from the artery, usually below the entrance of the profunda branch. Many surgeons believe that there is less apt to be swelling if the profunda is left intact.

Two stay sutures are placed about the vein and a longitudinal incision is made. The blood clot that presents is picked out with a fine clamp after which a glass tube about the size of a female glass catheter is inserted into the vein. It has been my experience that suction has to be continued for a considerable period of time until free bleeding occurs. This means passing the tube upward into the pelvis for 5 or 6 inches. If free bleeding still does not occur after this has been thoroughly evacuated by suction a catheter with the end removed is at

tached to the glass tube and passed upward at least to the bifurcation of the vena cava. At this time, with the exception of one case, bleeding has been free.

Following this, the vein is ligated above and below the incision and the intervening piece between the ligatures is excised.

If the long saphenous vein has not been exposed in the original procedure it should now be examined. In two of my cases the clot organized in the long saphenous and passed through it, opening into the femoral vein, thence upward into the iliac vein. If the vein contains a clot it should be sucked out and the vein doubly ligated. The wound is then loosely closed. As in this group of cases the thrombus extended beyond the point where a ligature could be applied, the postoperative use of anticoagulants was necessary.

*Use of Anticoagulants after Thrombectomy*—It is unnecessary for me to describe either the use of continuous heparin or dicoumarol as all surgeons are familiar with their use. However, I should like to describe the method of using *heparin subcutaneously*, by injections at two- to three-day intervals, as developed by Leo Loewe in New York. I quote from Loewe as follows:

'To accomplish a slower and more equitable absorption of heparin, the Pitkin menstruum was adopted as a vehicle. This menstruum was developed to regulate the rate of release of water soluble drugs injected intramuscularly or subcutaneously. The ingredients are gelatin, 15 to 30 per cent, dextrose, 5 to 12 per cent, acetic acid, 1 to 1.5 per cent, distilled water sufficient to make 100 per cent. The viscosity of the menstruum, which is predicated on the concentration of the gelatin and dextrose, determines the rate of liberation of the drugs, the greater the viscosity, the slower the liberation. In the preparations containing heparin the optimum percentages of gelatin and dextrose were 18 and 8 per cent respectively.

'Ampules containing varying proportions of heparin and Pitkin menstruum with or without vasoconstrictor elements were prepared. All ingredients apart from heparin were found to be inactive in control tests.

'The contents of the ampules were liquefied at 110° F., drawn up through a 2½ inch, 19-gauge needle into a previously warmed, sterile 5-cc. or 10 cc. syringe and immediately injected subcutaneously, preferably in the anterior or lateral aspect of the thigh. Intragluteal injections were also done in a limited number of instances. Although this method of administration was abandoned

because of too rapid absorption, further experience may eventually prove it to be just as effective as by the subcutaneous route. When two ampules were employed, the contents were thoroughly admixed in the syringe before injecting. The material congealed promptly following inoculation. The injections were administered with a minimal amount of discomfort to the patient. Some patients subsequently complained of pain, tenderness, and swelling at the site of inoculation, particularly when a large amount (3 to 4 cc) of the menstruum was used. This, however, did not prove to be a deterrent to further treatment, and symptoms promptly subsided upon cessation of therapy."

The results of Loewe's treatment are that it is possible now to heparinize a patient for ten days with possibly three to four subcutaneous injections during this time, at much less expense than formerly.

The tenderness in the area where the heparin Pitkin solution is injected becomes quite a problem as the patient may, about the time of the third injection, oppose it because of the pain entailed. As the process is improved, however, I feel certain that this one difficulty will be remedied. To those who have had to give heparin constantly for from five to ten days, this method in itself is a great improvement. The expense of the old method and the amount of fluid given during each twenty-four hours makes continuous injection almost impossible in these days of diminished nursing care.

#### REVIEW OF CASES

There are thirteen cases, in nine of which antecedent emboli were present, the remainder showing no evidence thereof. In three of the cases simultaneous thrombectomy of both the iliac and long saphenous veins on each side with ligation was done, as described below.

Of the thirteen cases, one was medical, namely an endocarditis with thrombus of the femoral vein. Two were preoperative, one immediately preceding a bilateral oophorectomy for extensive bilateral ovarian carcinoma, and one two weeks prior to hysterectomy for degenerating fibroids. This case (Case I) is reported in detail later.

Ten cases occurred postoperative as follows: two following pregnancy, one after cesarean section, one after cholecystectomy, one after prostatectomy, one after amputation of a leg for tumor, two after hysterectomy, one after recurrent attacks six years following the original thrombophlebitis preceded by herniorrhaphy, and one after a bumper fracture of the tibia.

Three of the above group had bilateral thrombectomy performed simultaneously by two surgical teams working at the same time. One patient (Case II) had a thrombectomy on the left side followed two weeks later by thrombectomy on the right side.

There were two deaths in this series, one in a patient with bilateral extensive carcinoma of the ovaries wherein the thrombectomy was performed simultaneously with the removal of the tumor. This patient died two weeks later of renal insufficiency with no evidence of any return of the original thrombosis.

Time is too short to analyze each of the thirteen cases in this series in which thrombectomy was performed. The procedure was primarily the same in each and the results in those who convalesced were satisfactory except that one patient has continued to have persistent swelling of the thigh and leg. The others have had a fairly rapid return to normal size of the leg and have complained of no interference with function. I should like, however, to describe three patients, since I feel that they present some of the important features concerned with this disease.

**CASE I**—A woman aged 46 years had been seen by a gynecologist who recommended hysterectomy for an extremely tender uterine fibroma which was fixed in the lower portion of the pelvis. The uterus extended midway to the umbilicus. Ten days later while awaiting operation acute phlebothrombosis occurred in the left iliac and femoral veins. I was called to see the patient at this time. There was no evidence then of pulmonary embolism. It was felt, however, that this patient would need hysterectomy in the near future because of a degenerating fibroid and that it would be advisable to remove the clot from the iliac vein beforehand. The clot was sucked out from the left iliac vein and there was no evidence of any clot in the lumen. There were, however, some old thrombi in the veins of the broad ligament.

This patient's convalescence was uneventful. She left the hospital two weeks after the hysterectomy.

**Comment**—This case was one of the few I have known in which *recurrence occurred within two weeks following a thrombectomy*. No evidence could be seen by the operating surgeon of occlusion of the vein.

**CASE II**—This patient had a cesarean section performed for a premature separation of the placenta in a seven months' pregnancy. A live baby resulted, and the postoperative convalescence of the mother was extremely smooth. There was no postoperative elevation of temperature and no complaint of abdominal or thigh pain. The patient left the hospital on the twelfth postoperative day. Three

days later she complained of an acute attack of pain in the chest. She was readmitted to the hospital. Her temperature rose to 103° F. Three days after admission a ray of the left chest showed irregular consolidation. Her physician had carefully gone over both legs and thighs, there was no difference in their circumference by mensuration. There was no tenderness.

Ten days after her admission the patient had a sudden swelling and pain in the left thigh. I was called to see her on the next day. Under local anesthesia the left femoral vein was exposed. A clot was removed. I did not feel, however, that I had reached the upper end of the clot because free bleeding was not encountered. It was in a strange hospital and there was some difficulty in getting the proper kind of tube, consequently I did not insert a catheter high up in the iliac vein as I should have done, and I did not get as free bleeding as I wished. Her postoperative condition improved for about six days. Her temperature receded almost to normal, and she had no pain or swelling in the leg. However eight days after thrombectomy, she had a sudden attack of pain in the right chest, with elevation of temperature. A ray showed a cloudy right lung, with not as great consolidation as on the other side. Up to this time there had been a question whether this was a virus pneumonia followed by a phlebothrombosis, or whether the initial infarct antedated the appearance of the phlebothrombosis by ten days.

Eight days after the second attack of pain in the chest, phlebothrombosis developed in the right thigh. This time, under spinal anesthesia, a clot was removed from the left femoral vein, followed by free bleeding. The patient, however, began to go into collapse during the administration of the low spinal anesthesia and her collapse continued after the removal of the clot. She was taken to her room in a serious condition. She died three days thereafter.

An autopsy was performed. I quote from the *autopsy report*:

*Lungs*—The right lung is completely collapsed and attached to the chest wall by numerous strands of fibrin and purulent exudate. There is about 500 cc of a fibropurulent fluid in the right pleural cavity. The right lung weighs 400 gm. The left lung is adherent at the apex to the chest wall by old fibrous adhesions. About 100 cc of thick purulent exudate is present in the left pleural cavity. The left lower lobe is completely collapsed. The left upper lobe is well aerated and pink in color. Examination of the branches of the pulmonary artery shows a large thrombus in the lumen of the right vessels with branches running to all of the lobes. This thrombosis is yellow in color and adherent to the intimal layer of the vessel. On the left side there is a similar appearing thrombus in the lumen of the branch of the left pulmonary artery leading to the left lower lobe. There is no thrombus found in the lumen of the main pulmonary artery. No mediastinal node is found.

*Uterus*—The uterus is small and anteverted. The operative wound in the anterior wall of the myometrium is well closed by chromic catgut sutures which are still present. Adherent to the anterior surface of the endometrium is some granular pink tissue which grossly resembles placental tissue. The tubes and ovaries are essentially normal.



The veins in the broad ligament of the right side are natural. On the left side, the vessels at the base of the broad ligament contain distinct well organized thrombotic tissue. The vena cava and both iliac veins are opened. The right vein contains some postmortem clot which is lying free in the lumen of the vessel. On the left side, however, the blood clot in the iliac vein is well organized yellowish pink in color and adherent to the vessel wall. The thrombus runs up into the vena cava for a distance of 3 cm. At the upper end of this thrombus the blood clot is distinctly postmortem in nature. The branch of the hypogastric vein leading from the left iliac vessel is also thrombosed as are those of the veins in the pelvis on the left side. In the region of the left femoral vein the thrombus in the lumen of the vessels appears relatively fresh but distinctly postmortem in character.

*Comment*—My impression of this case is that, if I had been successful in removing the clot on the left side, there probably would not have been an extension of the process to the right side nor would there have been the later casting off of emboli. The unusual picture in this case consists of the time element, that is, the development of the signs in the thigh ten days after the original infarct in each case. This was obviously a case which showered emboli from the pelvic veins although an examination of the uterus showed no evidence of broad ligament involvement.

CASE III—A man aged 55 years, was operated upon for an inguinal hernia six years ago. His convalescence was complicated by a thrombophlebitis of the left thigh and leg. I am unable to determine whether this was a deep or superficial phlebitis. Following his convalescence he was well until six weeks ago when he had an attack of phlebothrombosis of the superficial veins below the knee. After two weeks' rest in bed he was allowed up. After being up and about for a week, the process extended to the long saphenous vein. He was put to bed again for three weeks, with elevation and local heat. The phlebothrombosis gradually extended to the saphenous triangle.

On the day before I saw the patient he had a sudden severe attack of pain in his right chest, accompanied by shortness of breath but no bloody sputum. He was transferred to a hospital and operated upon. The long saphenous vein contained a clot which extended into the iliac vein. The femoral vein was exposed distally. It did not contain any thrombus. The thrombus was sucked out of the iliac vein and the saphenous vein was ligated and a portion excised. He was given heparin in Pitkin's solution intramuscularly. His convalescence was uneventful.

*Comment*—In the early stage, it would have been so easy and safe to perform under local anesthesia a proximal ligation on this patient. He would have been saved weeks in bed, as he could have been mobilized immediately after operation.

## SUMMARY

I believe that thrombectomy is a relatively safe procedure and that if followed by the use of an anticoagulant it will serve as a life saving procedure in patients who have phlebothrombosis of the femoral and iliac veins. It does not usually seem necessary to do a proximal ligation in these cases by exposure of the iliac veins in the pelvis, although in the occasional case this procedure might be called for.

# CLASSIFICATION AND TREATMENT OF SWOLLEN LEGS

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THE cause of swollen ankles is not always easy to determine out of the discussion edema produced by cardiorenal disphantiasis and deep venous obstruction, there are three types ing which are of great concern to the patient and may present problem to the doctor on whom the onus of diagnosis and treatment falls

## SIMPLE VARICOSE VEINS

The most common one of this group is the edema caused by varicose veins. For the past fifteen or twenty years the literature has been full of methods of treatment of this condition. The great enthusiasm which ushered in the use of sclerosing solutions to obliterate the lumen of the dilated veins has waned. In its place a combination of *high ligation and injection* has come into practice. It has been found necessary in this operation to ligate not only the main saphenous vein at the femoral bulb, but also the group of four or five collateral branches which come in just below the junction with the femoral vein. A second point of ligation should be done where the vein curves around the inner side of the knee. In the very extensive cases it is wise to determine by the use of a tourniquet where the deep communicating branches come in and tie at these points also.

Frequently injection is done at the same time as the ligation but I have come to feel that better results are obtained if injection is done at a later period, since it is found in many instances that the ligated veins obliterated themselves without the added irritation of a sclerosing solution. The fine points of technic have been given so completely in other articles that space will not be given here for it. Suffice it to say that the majority of patients treated in this way have great relief from pain and from the swelling of the ankles and the feeling of heaviness and fatigue produced by the enlarged veins. The follow up figures

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have shown a much more permanent obliteration and less recurrence of varicosities than any other form of treatment.

#### LYMPHEDEMA WITH ULCERATION

The second type of swelling which has been studied does not respond as readily to treatment nor is the etiology as clearly understood. This type starts with a patch of redness, edema and tenderness over the shin or ankle and slowly develops into an extensive lymphedema with ulceration. Varicosities are usually present, but not always. The condition is helped by rest and elevation and aggravated by standing and exercise. Unna paste boots alleviate the condition while they are worn, but there is almost immediate recurrence when they are removed. In one case which I treated, local ligation of veins in areas aggravated the condition.

Various causative factors have been suggested in this group. Trichophytosis is often present and Thompson feels that the lymphatic block is due to an allergic phenomenon caused by the presence of this infection. All of these patients should have scrapings taken from between the toes to see if the fungus is present. Wright thinks the lymph stasis may be due to some form of virus infection. It has also been suggested that the condition begins as a localized patch of myxedema from a hypothyroid state. Certainly the clinical course suggests some form of low grade inflammation, although, in my experience cultures of these tissues have never grown any type of organism. However it is advisable to clear up all foci of infection. The majority of these patients have flat feet which cause pressure on the plantar circulation. As a result, trophic changes in the skin, atrophy of the leg muscles and an inflexible foot develop. The patient cannot raise himself on his toes. The calf muscles no longer contract enough to help keep the blood pumped up through the veins. Here is an additional factor for producing congestion.

As time goes on the redness and edema gradually extend around the leg and cause pressure on the lymphatics which in turn causes a more intense edema. Scar tissue is constantly laid down in the edematous subcutaneous layers and the longer the condition exists the denser this layer becomes. In the more advanced cases an inch or more of gristle-like scar tissue may be found replacing the normal subcutaneous layer. The lymphatics in this tissue are completely obliterated and the veins are held wide open in a rigid casing. The skin over this area

becomes pigmented, appears thin and shiny and large indolent ulcers develop. Rest and elevation and an Unna paste boot are again palliative treatment but not a cure. Something must be done to soften the scar tissue and reestablish the lymphatics.

Saylor, Kovacs, Duryce and Wright have reported the results of *iontophoresis* on this type of pathologic change and feel that it accomplishes two things: (1) it increases local circulation and removes tissue fluids, (2) by producing local diaphoresis it reduces edema resulting from hydrostatic pressure and promotes healing. Physiotherapy offers little or no help. Whirlpool baths may clean the ulcers but do not soften the scar tissue. Bancroft, Stanley-Brown and Taylor reported a series of cases treated by a *modified Kondoleon operation*. In this procedure incisions are made longitudinally down either side of the leg. They are begun about 2 inches above the scarred area and extend an equal distance below it. They are then deepened until normal tissue is reached. It is always necessary to go through fascia and occasionally through muscle to bone if the muscle is involved. Tension is released by this procedure and the wound gapes wide open. Adequate hemostasis must be obtained and this is difficult since the vessels are firmly embedded in scar tissue and suture ligatures have to be used. The wounds are dressed with gauze packing soaked in 1:5000 acriflavine solution. This treatment is continued for a week or ten days when the sloughs have separated and clean granulation tissue appears. Skin grafts are then placed over the surfaces in order to get them epithelialized before scar tissue can again form. Thiersch or split thickness grafts made with a dermatome usually take well. If there is any doubt as to the sterility of the tissues, pinch grafts can be used and give a rather high percentage of takes even in the presence of low grade infection. It is important to keep the patient in bed with moderate elevation of the legs until the wounds are completely healed. After he is ambulatory, he should wear an Unna paste boot for about six months. Follow-up studies in these cases show that the scar tissue resorbs and the subcutaneous tissues become normal in consistency. It is assumed that the lymphatics become reestablished. High ligation of the saphenous veins should be done in these cases to help relieve tissue congestion.

The real problem in this group is how to treat the leg when the first spot of redness and edema occurs. So far, no satisfactory method has been found since the etiologic factors are not clearly understood.

## SOFT PAINLESS SWELLING OF THE ANKLES

The third condition manifests itself as a soft painless swelling of the ankles. It becomes more intense as time goes on but rarely extends to or above the knee. In one such case the basal metabolic rate was found to be minus 31, in another minus 22. A third case which was studied was that of a young girl who for five or six years had been on a very deficient diet, with almost no protein and few fresh vegetables. Elastoplast bandages were used on both legs at first to control the swelling. She was put on a high protein diet and started on intramuscular injections of thiamine hydrochloride three times a week. Thiamine by mouth cannot be absorbed sufficiently to get the desired effect. Not until she was receiving 50 mg daily of the thiamine was the swelling controlled enough to let her go without bandages. She is now free from edema but the swelling appears if she misses her injections for a day or two. Also on this regimen she feels better, is less nervous and can carry a rather exacting job much more easily. In some instances thiamine dosage as high as this will cause tachycardia and nervousness, hence patients on this regimen should be watched closely. There is still much to be learned about this thyroid-protein-vitamin B deficiency syndrome.

## SUMMARY

Swollen legs were divided into three groups

An attempt was made to explain the etiology in each group

Treatment of the three conditions was discussed

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## NEW METHODS OF HEMOSTASIS

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THE art of surgery as it is practiced in this year of world conflict depends for its success on three astonishingly recent achievements, and these now constitute three techniques—control of pain, prevention of infection, and checking of hemorrhage. When a modern artery clamp is handed to the surgeon in the operating room it is easy to forget that its full use could not be developed until anesthesia gave time for meticulous surgery in a dry field, and asepsis made it possible to introduce foreign bodies into a wound and leave them there.

It is always a temptation to indulge in an historical review when discussing recent developments of a technique. Space preventing, however, the reader is urged to supplement this brief presentation with a truly enjoyable monograph by Samuel Clark Harvey<sup>1</sup> which covers the history of hemostasis from the styptic medicaments of the ancients through the long ages of the actual cautery down to the development of the ligature and the hemostat.

In connection with these mechanical devices it should be added that in recent years the silver clip, proposed by Cushing<sup>2</sup> in 1911, has been added as a substitute for ligature, and that much thought and study have been devoted to the choice of ligature material, absorbable and nonabsorbable, heavy and light. Recently, also, as a curious and characteristic swing of the pendulum of thought, the electrocoagulating current for small bleeders and the cutting current for bloodless incision have revived the never entirely discarded principle of the actual cautery.

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From the Surgical Pathological Laboratory of the College of Physicians and Surgeons, Columbia University, and the Department of Surgery, Presbyterian Hospital, New York City. The work on oxidized cellulose described in this paper was done under a contract recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and Columbia University. The gauze and cotton were supplied by Eastman Kodak Research Laboratories, Rochester, N. Y. (U. S. Pat. No. 2,213,990) through Parke, Davis & Company, Detroit, Michigan.

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## BASIC PRINCIPLES OF SOUND SURGICAL PROCEDURE

With these techniques in common use in clinical surgery today we are now able to secure healing by first intention in the vast majority of clean wounds, no matter what the size. It seems improbable that any new development will alter the fundamental principles on which good surgery is based. These must be constantly reiterated. The temptation to neglect them, because of some new and intriguing device, too often leads to disaster. Whatever the new methods, *operative technic must include*

- 1 The prevention of undue contamination
- 2 The meticulous control of bleeding
- 3 The reduction to a minimum of the amount of dead tissue and foreign bodies

Corollaries to this are

- (a) Gentle handling of the tissues
- (b) Avoidance of mass ligation
- (c) Careful choice of ligature and suture material
- (d) Avoidance of ischemic necrosis by tight suture
- (e) Approximation of tissues without undue tension
- 4 The collapse of all dead spaces and careful approximation of the wound edges
- 5 The protection of the wound from further trauma

These principles apply with modifications to the drained operative wound, and to the accidental wound which it is desirable to repair. Where hemostasis is secure, drainage, which in itself predisposes to infection, may sometimes be avoided and deliberate and accidental wounds closed which might be otherwise left open.

## PROGRESS IN THE TECHNIC OF HEMOSTASIS

In connection with the second of these fundamental principles it is interesting to remember that the importance of the clotting mechanism as a factor in hemostasis was not recognized until the eighteenth century, and that only in the twentieth century has it been possible to accelerate that mechanism. The impetus came naturally as the field of surgery was extended, and a type of bleeding was frequently encountered for which the ligature or the silver clip did not suffice.

Bleeding from vessels in, for example, brain, liver, kidney and vascular tumors was difficult to control because of the friability of the tissues. Ooze from vessels of small size, as on the surface of the dura



or in the substance of the brain and spinal cord, prolonged operating time and obscured the field. In revision of drainage in long standing infection or in decortication of the lung, control of vessels in the tough, slippery cicatricial tissue (sometimes almost cartilaginous in consistency) constituted a serious problem. In these different situations the clamp and ligature either tear out or cannot be applied at all. The surface weeps, constant sponging is necessary, and, in clean wounds if they are closed, there is always danger of continued ooze and hematoma formation. Such clean wounds can be drained for twenty-four to forty eight hours to take care of just such accumulation of blood, but this constitutes another hazard, allowing for the entrance of organisms secondarily in a field full of rich culture medium.

In the open contaminated or infected wound *packing* or *tamponade* will check the ooze. Every surgeon has at some time blessed the 5 yard roll which saved the patient's life in a rupture of the liver. But following such immediate hemostasis there is always the problem of the removal of the packing with the secondary hemorrhage which so often follows, and which usually necessitates repacking. Such dressings often require anesthesia because of the pain when the gauze is pulled away from the raw surface. Where the wound is contaminated and packing has been used to control bleeding the gauze even the silk tampon can obstruct drainage, and seal up infection which might otherwise be minimal and which, when sealed, gets a brisk start.

With just such problems in mind a first step was made when *natural* clotting agents were introduced. *Striated muscle* was first proposed in 1911 by Cushing<sup>2</sup> in neurosurgery and was used independently by Horsley.<sup>3</sup> Its use was later extended to replacing tissue in liver biopsies, for example, and in drill holes in bone made for one or another purpose. The thrombokinasase liberated by the damaged muscle and the physical presence of this 'natural' packing were usually effective. Again however, there was a chance of contamination for the muscle had often to be taken from another operative field, and time was also occasionally an urgent factor.

**Plasma Fractions**—Cushing, to whom hemostasis was a constant concern, anticipated a good deal of very recent work in a footnote in the same article in which he discussed the use of muscle and the silver clip. This is worth quoting: 'If Bernheim's<sup>4</sup> conclusions (J A M A 1910), that the walls of the blood vessels possess more active clotting elements than do other tissues, prove to be correct the walls

of preserved vessels may be applicable for this purpose, or the fibrin from whipped blood might be so prepared that it could be immediately plastered on bleeding surfaces, just as cotton is now used, and thus obviate the necessity for any subsequent replacement." This proposal resulted in the study by Grey<sup>5</sup> of sheep's fibrin in small blocks, which he thought more useful than cotton in hemostasis, and found relatively nonirritating in animal tissues, and by Harvey<sup>6</sup> who thought a paper-like substance made of fibrin would be less cumbersome, and made such papers from beef fibrin. Further studies of fibrin used alone in hemostasis were not reported for some years.

Twenty years after Harvey's discussion of fibrin the work of Seegers<sup>7, 8</sup> and his colleagues focused attention on another plasma protein, i.e., thrombin. A year later<sup>9, 10</sup> a highly potent purified water-soluble thrombin obtained from beef plasma was used as a hemostatic spray in animal studies, and in a small series of clinical cases. Two years later Lozner<sup>11</sup> and his associates reported control of hemorrhage in *small wounds* induced by standard trauma in normal persons and in nine additional subjects, patients, seven of whom had hemorrhagic diatheses, who were bleeding spontaneously from small wounds. In a further clinical study by Seegers<sup>12</sup> and his associates 225 cases were reported treated with "Thrombin Topical."

Meanwhile a huge piece of investigative work was undertaken in the Department of Physical Chemistry of the Harvard Medical School. A series of papers entitled "Studies on Plasma Proteins" report chemical, clinical and immunological studies on the products of human plasma fractionation. The most recent paper<sup>13</sup> is Number 31 in the series (JAMA, November 11, 1944), and the most comprehensive and easily available reports are fourteen of the series in a single issue of the Journal of Clinical Investigation, July 1944, to which the reader is referred for further bibliography.<sup>14, 15 and 21, 22</sup> Eight of the products have been subjected to clinical trial, and of these *thrombin*, *fibrinogen* and *fibrin* in the form of foam, have been used to accelerate clotting. The fibrinogen in conjunction with thrombin is also useful in the formation of an adhesive clot to seal together two surfaces, notably a skin graft on a prepared bed. This method, incidentally, is the same in principle as that originally reported by Sano<sup>16</sup> and her collaborators in *The Surgical Clinics of North America* for December 1943. It is not, however, essentially a matter of hemostasis.

For the control of bleeding in neurosurgery the fibrin foam which is absorbable and nonirritating is used in conjunction with soluble

*thrombin* The foam, to quote Ingraham and Buley,<sup>12</sup> has a honey comb structure composed of fibrin with air spaces of various sizes. When it is used as a hemostatic agent, three bottles are supplied. One of these contains sterile fibrin foam, another dried human thrombin and the third 30 cc. of sterile isotonic solution of sodium chloride. At the time of use the saline solution is added to the dry thrombin, solution takes place rapidly. Pieces of fibrin foam are soaked in the thrombin solution and are then ready for use in hemostasis. The fibrin foam, which is firm and somewhat brittle in the dry state becomes rubbery and shrinks as fluid enters the air spaces. The authors report its use in 169 neurosurgical procedures and their technic is as follows: 'For use in any neurosurgical operation the dry fibrin foam is cut up into pieces of various sizes for use in the different types of bleeding which may be expected in that particular procedure. As the operation gets under way, these are placed in the thrombin solution so as to be ready for instant use. If minute fragments are wanted for control of small bleeding points, the moist fibrin foam can be picked up with forceps and cut or pulled apart. At the time when bleeding is encountered, a piece of the fibrin foam is selected and held firmly in place with a cotton pledget, which takes up excess moisture. Suction is often useful when applied over the pledget. It will then be possible to remove the pledget without dislodging the fibrin foam. The fragment can be molded to conform to the shape of the surface and will retain the configuration after excess moisture has been removed. Should additional hemostatic material be required because of unforeseen circumstances in the course of the operation, dry fibrin foam will be suitable for use after soaking in the thrombin solution for one minute. They also report early clinical trials in general surgery, treating oozing liver surfaces and abdominal wounds in jaundiced patients, and in radical mastectomies, nephrotomies, gynecologic procedures, and thoracic surgery. Bleeding tooth sockets in hemophiliacs have also been controlled with these preparations.

**Absorbable Gauze and Cotton (Oxidized Cellulose)**—Another absorbable and relatively nonirritating material has been the subject of investigation at the College of Physicians and Surgeons of Columbia University. Originally our search had not been for a hemostatic agent but for an absorbable film of some kind which could be used to prevent adhesions. At the suggestion of Dr. Hans Clarke of the Department of Biochemistry, the writer<sup>24</sup> in 1941 studied the response of various animal tissue to soluble cellulose. This, in the form of oxidized

cotton, had just been prepared by Kenyon and his collaborators<sup>25 26</sup> (US Pat No 2,232,990) in the Eastman Kodak Research Laboratories, and was, through the courtesy of Dr Kenyon, studied in advance of his publication. When it was found that the material was nonirritating and disappeared in animal tissues leaving a minimum of scar, other possible uses immediately came to mind, and even before the laboratory investigation was reported, the cotton was used in clinical cases in neurosurgery as a carrier for thrombin by Dr Tracy Putnam<sup>27</sup> of the Department of Neurosurgery, who found it of considerable value.

Cellulose in any form—gauze, cotton or paper—can be oxidized by nitrogen dioxide so that it is soluble in dilute alkali. This is because of extensive carboxyl group—COOH—formation which renders the cellulose somewhat acid. The degree of oxidation determines the carboxyl percentage, and the physical properties of the finished product—softness, absorbent quality and solubility. The material is slightly degraded by the oxidation, loses some of its tensile strength, and occasionally is slightly off the original white color. It does not withstand sterilization in the autoclave, but can be boiled in water (without the soda so often used for instruments) for three minutes. This sterilization is not, of course, adequate for spore formers.

As now prepared in the Research Laboratories of the Eastman Kodak Company, Rochester, New York, and sterilized, by formaldehyde sterilization, by Parke, Davis and Company, Detroit, Michigan, the gauze and cotton are slightly harsher than unoxidized material, are satisfactorily absorbent, are free of nitrogen, and are slowly soluble in 0.15 molar solution of sodium bicarbonate, whose pH approximates that of the blood. As reported by the writer<sup>28</sup> in a large number of implants in animal tissues—connective tissue, muscle, bone, serous and synovial cavities, and parenchymatous organs—brain, thyroid, liver, kidney and spleen the material has proved relatively nonirritating, and has been completely absorbed in variable lengths of time, depending on the amount introduced, the extent of operative trauma to the tissue, and the amount of blood present.

At the time of our first report, all that was expected was that the oxidized gauze and cotton would control hemorrhage as would ordinary gauze but would not have to be removed. The cotton was already in clinical use as a carrier of thrombin. Further animal studies were needed, obviously, and these were undertaken. Freely bleeding lacerations of kidney, spleen and liver were packed with oxidized gauze in

considerable quantities, and with plain gauze as control. Some of the wounds were left open and some were closed.

In handling the soluble gauze it became apparent that it had *unexpected hemostatic action in its own right*. Unlike ordinary gauze it would swell when impregnated with blood, and turn black. Bleeding was more rapidly controlled, and in sections of the organs later, it was seen that the material had adapted itself to the wound space and that no considerable amount of clot was present in the meshes of the gauze. This tallied with the observation that in late cases no large amount of scar tissue was found, indicating that no extensive clot had been organized.

The material went slowly into solution, and, in closed wounds was rapidly absorbed, passing, probably often directly, into the blood stream and out through the kidneys. In addition, some obviously passed through phagocytes, not as particulate matter, but in solution, causing intense basophilic staining of the cytoplasm. There was never any acute inflammatory reaction, however, unless there was associated infection or other more irritating foreign material, such as the marking silk sutures employed.

In serous and synovial cavities, cysts not infrequently formed. These were thin walled, without evidence of inflammation, and were filled with thin fluid in which the polysaccharide could be demonstrated in the early days, but from which it soon disappeared. In a series studied at varying time intervals we came to the conclusion that eventually such cysts reabsorbed.

Preliminary studies indicate that the material, possibly because of its acidity, delays the formation of callus in clean experimental fractures. It would thus be contraindicated in open reductions, even if, as happened in the experimental animals, repair was eventually complete, but it might still be used for hemostasis in lacerated wounds with compound fractures left open where the remnants would be removed at an early dressing.

In addition to these observations on the response of the tissues, other studies of oxidized cellulose were pursued independently. Heidelberger and Hobby<sup>29</sup> had predicted that, because of the cellobiuronic acid units formed in the process of oxidation of cellulose, the products might be expected to react specifically with Type III or Type VIII antipneumococcus horse serum, and this proved to be the case. Attempts to confer active protection upon mice with oxidized cellulose failed, but the same amount of the Type III and Type VIII specific

polysaccharides also failed to protect against the extremely virulent strain of Type VIII pneumococcus chosen. Studies of the immunological aspect in humans are in progress.

Also we were apprised of the unpublished work of Kabat, Hennig, and Victor<sup>30</sup> in which they reported intravenous administration of the sodium salt in solution to rabbits. It was rapidly eliminated through the kidneys without breakdown and its rate of disappearance from the blood stream and excretion in the urine could be measured using precipitin tests with Type III and Type VIII antipneumococcus horse serum. It did not affect the sedimentation rate, but was somewhat pyrogenic. They also reported five autopsies in which swelling and vacuolization of the epithelium of the convoluted tubules were noted. In autopsies on twenty-six animals in our laboratories this finding was inconstant. In the clinical case in which death from pneumonia occurred three days after operation, similar vacuolization was noted. We are not inclined to believe that this is of great significance.

After due consideration of all this laboratory data the material was released for clinical investigation in general surgery.<sup>31</sup> The most extensive clinical trials to date have been at the Columbia-Presbyterian Medical Center and the Mayo Clinic.<sup>32, 33</sup> No thrombin was used in our trials here in general surgery or in genitourinary surgery, nor in a series of control cases in neurosurgery. In the first hundred odd cases at the Mayo Clinic thrombin was used. In more recent cases the same surgeons have used the gauze or cotton dry, and have reported favorably.

To date no untoward results have been reported with the material. It is necessary, naturally, in certain situations where there may be rubbing over an oozing surface to which the gauze has been applied, to secure it in place with a suture. This is not necessary when it is packed into a cavity.

Many of the wounds have been closed. Some have been drained for reasons other than the presence of the gauze. From such drainage tracts particles of blackened, blood-soaked gauze have sometimes come away, and also thin brown fluid.

The gauze has been very promising in large oozing open wounds requiring tamponade where the tampon must later be removed. Here, if the oxidized gauze is used to line the cavity, at the end of twenty-four or forty-eight hours although there may be undissolved material in the wound it is not adherent and can be removed with forceps or by irrigation without causing further bleeding.

Since the report<sup>25</sup> of our own first seventeen clinical trials we have had an opportunity to study more cases, and to hear informal reports from investigators in other hospitals, including those of a few individual Army surgeons, not however, those handling fresh casualties. Our own cases to date are distributed as follows:

#### HEMOSTASIS WITH ABSORBABLE GAUZE—OXIDIZED CELLULOSE

##### *Total of Clinical Cases To Date*

Liver	18
Retroperitoneal or retropleural tissue	16
Infected wounds	8
Bone	5
Biopsy or excision (lymph nodes or tumor)	6
Amputation stump	1
Thyroid	1
Nasal cavity	3
Tooth socket (hemophilic)	1
Rectum	1
Prostate	16
Kidney or kidney bed	8
Circumcision	1
Urinary bladder	1
Vaginal wounds	2
Neurological	27
	<hr/> 115

The hemostatic agent was a convenience in all of these cases. Packing was mandatory in a few only, that is, permanent gauze packing. Two of the liver cases were left lobe lobectomies for tumor. The left hepatic artery was ligated but there was still oozing which the gauze controlled. The first of the series was a wound containing a torn internal carotid artery, which had already been packed with gauze. When this was withdrawn on the third day brisk bleeding ensued, requiring repacking which was then done with the absorbable material. It has been a great convenience in the prostatectomies and postoperative check cystoscopy has not shown any remnants of gauze in the bladder.

In two cases which came to autopsy, one three days and one three months after operation, we have had an opportunity to confirm our belief that the reaction in human tissue is similar to that in the experimental animals, and that the material is absorbable and nonirritating.

**Absorbable Sponge**—A personal communication from Dr. Richard U Light informs me of still another absorbable substance now undergoing animal and clinical tests. This is Absorbable Sponge (Upjohn), made by foaming a specially prepared gelatin solution, which is further processed and sterilized. The sponge, when dry, is a light, off-white, reasonably tough, porous substance that may be readily cut by a sharp instrument into any shape or size desired. It is light in weight (9 mg per cm<sup>3</sup>), and is a very efficient sponge, engorging about fifty times its weight of water or forty-five times its weight of well agitated, oxalated whole blood. Since it is basically a gelatin product, it is non antigenic.

In use the sponge is dampened with a thrombin solution, then blotted to a damp-dry. The squeezed-out sponge is applied to the bleeding area, where it quickly imbibes blood, which, coming in contact with thrombin, clots. The clot, and the matrix upon which it is embedded, is left undisturbed. Physiological absorption takes place in from fifteen to twenty days, and tissue reaction is minimal.

#### SUMMARY

I have briefly reviewed the progress of the technic of hemostasis with emphasis on the fundamental principles of sound surgical procedure, and discussed in some detail soluble thrombin, fibrin foam and absorbable gauze and cotton (oxidized cellulose) as agents to promote hemostasis. Further laboratory and clinical investigation of the properties of the substances are in progress, with a view to determining their fields of greatest usefulness.

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## PRE- AND POSTOPERATIVE CARE OF THE ' POOR RISK' PATIENT

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With the increasing age of the population and the larger number of elderly patients subjected to operative procedures, greater attention is being paid to the management of the 'poor risk' patient. Cardiac, pulmonary, renal and hepatic disorders, malnutrition, anemia, infection, vitamin deficiency, biochemical imbalances and many other conditions that formerly precluded, to a large group of patients, the possible advantages of surgery, are now frequently controlled and operations are performed with conspicuously lowered morbidity and mortality rates. Of the total effort to effect a cure, the operation is but one part and, in the case of the 'poor risk' patient, may be far less important than the preoperative and postoperative care.

It is obviously impossible, in the short space allotted, to consider more than briefly a few of the many conditions that make a patient a poor risk. We shall discuss very briefly the management of patients with certain metabolic imbalances, vitamin deficiencies and disturbances of cardiac, hepatic, renal, gastrointestinal and respiratory mechanisms and mention certain precautions relative to anesthesia and mobilization of the patient.

### METABOLIC ASPECTS OF THE POOR RISK PATIENT

In the evaluation of the poor risk patient, ever increasing attention is being paid to metabolic factors including fluid electrolyte balance, the vitamins and plasma protein levels.

**Fluids and Electrolytes**—The determination of the fluid and electrolyte balance is not only of theoretic but of practical importance. Vomiting, secondary to obstructive lesions and manition due to carcinoma, diarrhea and the like are among the commoner causes of dehydration and the loss of electrolytes. With pyloric obstruction there

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is loss of the chloride ion which, if of sufficient degree, may result in hypochloremia and alkalosis. With diversion of pancreatic juice and bile, as by duodenal fistula, the sodium ion is chiefly lost and acidosis may result. When fluids are lost from the lower intestinal tract (jejunostomy, ileostomy or diarrhea) the body is thereby deprived of electrolytes<sup>5</sup>.

*Dehydration* may be evidenced clinically by dry tongue and mucous membranes and diminished tissue turgor as well as by laboratory tests including specific gravity of blood and urine, hematocrit determination and the level of plasma proteins. The average patient who is not losing fluids abnormally, should receive approximately 3000 cc of fluid daily and excrete 1500 cc of urine with a specific gravity of about 1.015. If loss of fluid from other causes occurs this should be replaced by an equal volume either by mouth or parenterally. If the patient is unable to take fluid by mouth, the fluid deficit from vomiting, fistulas, diarrhea and so forth is replenished by infusion or hypodermoclysis. Saline must be used judiciously in patients with renal disease or hypoproteinemia lest edema occur. Except for replacement of excessive loss of fluids containing chloride ions (e.g., vomitus, sweat) by normal saline intravenous or subcutaneous administration of glucose in distilled water will safely maintain fluid balance. The patient who is a poor risk because of conspicuous dehydration may require larger volumes of fluid (6 per cent of body weight per day in addition to the above) but care must be taken not to overburden the circulation.

To combat *acidosis*, sodium lactate as one sixth molar solution will raise the carbon dioxide combining power of the plasma. Approximately 60 cc per kilogram of body weight will raise the carbon dioxide content by from 25 to 35 volumes per cent when initially it is under 25 volumes per cent<sup>5</sup>.

**Plasma Proteins**—The importance of plasma proteins in maintaining the ability of the plasma to retain water is well known. Hypoproteinemia may be responsible for poor wound healing, malfunctioning anastomotic stomata in the gastrointestinal tract and, especially following the administration of saline solutions, the occurrence of observable edema. Pulmonary edema may occur in the presence of low plasma proteins although the patient may be in negative water balance. In addition, recent work indicating the low antibody titer of hypoproteinemic patients helps to explain their increased susceptibility to infection.

The quickest and surest way of restoring the protein deficiency is

the administration of whole blood or plasma. In addition, lyophile serum and amino acids may be given. With some diseases there may be defective production of digestive enzymes and in such cases pre-digested foods or amino acids and glucose may be fed.

**Vitamins**—The poor risk surgical patient is also likely to suffer from one or several vitamin deficiencies. Vitamins are no longer considered as substances that are useful only in the prevention of relatively unusual conditions such as scurvy, beriberi and pellagra but as elements necessary for basic normal biochemical changes in the body.<sup>10</sup> Thus lack of vitamins may be manifest in functional disturbances long before the gross clinical picture of a deficiency disease is evident.

Some malnourished poor risk surgical patients may exhibit the signs of deficiency of one or more vitamins and these are readily correctable, but many other patients give no clinical evidence of such lack and it is only when some complication, such as poor healing of a wound, unexplained hemorrhage or toxic psychosis occurs that consideration is given to possible deficiency.

**Vitamin A**—While deficiency of this vitamin has as its initial symptom night blindness its surgical importance lies in the changes produced in certain specialized epithelial structures. Metaplasia of the bronchial and tracheal epithelium with loss of cilia may result in retained secretions and increased likelihood of postoperative pulmonary complications. When possible, the poor risk patient should receive in the preoperative period, vitamin A therapy in the form of haliver oil or vitamin concentrates.

**Vitamin B**—Marked deficiencies of vitamin B are evidenced classically in pellagra and beriberi with conspicuous disorders of the skin and nerve, but it is with that most important function—tissue respiration—that members of the vitamin B complex are basically concerned. As respiratory enzymes at least three components of the B complex—thiamine, riboflavin and nicotinic acid—are important in carbohydrate metabolism. The production of energy from carbohydrate is conditioned by the quantity of vitamin B present in proportion to the rate at which the carbohydrate is oxidized.<sup>10</sup> Factors which contribute to avitaminoses B in many surgical conditions are fever, vomiting and the administration of large amounts of dextrose. Fever causes hypermetabolism with increased energy requirements, vomiting prevents the absorption of vitamins from any normal foodstuffs which may be taken. Glucose administration though the only available method of

alimentation in many instances, increases the utilization of coenzymes without furnishing any replacement"<sup>11</sup>

For many days or even weeks in the preoperative and postoperative periods, the "poor risk" patient may receive no feedings by mouth or an inadequate diet. During this period, parenterally administered glucose solutions in large amounts may be associated with the picture of acute thiamine deficiency (edema, neuritic pain, tender nerve trunks, etc.) These signs and symptoms, including the edema which has been attributed to the use of saline solution as a vehicle for the glucose, or to the use of excessive amounts of fluids, may disappear after the administration of an adequate amount of thiamine.<sup>11</sup>

The administration, therefore, of those available members of the B complex to patients on prolonged parenteral therapy will further normal cellular metabolism and help avoid complications.

**Vitamin C**—In addition to the many other factors that influence the process of wound healing (anemia, hypoproteinemia) deficiency of vitamin C may have a pronounced effect. A deficiency of vitamin C as determined by fasting plasma ascorbic acid levels has been found in a majority of hospital patients with a variety of pathological conditions.<sup>12</sup> Important with regard to those patients on the borderline of a deficiency is that following operation the fasting level of plasma vitamin C shows a drop with a gradual return to the preoperative level. During the first few postoperative days injected ascorbic acid disappears from the circulation at an unusually rapid rate.

It has been suggested<sup>13</sup> that "the deficient patient should receive 1 gm. of ascorbic acid daily for ten days before any surgical procedure is attempted and this should be continued until wound healing is complete." This overabundance of vitamin makes unnecessary determinations of ascorbic acid levels in plasma or urine which, in themselves, might be misleading because they do not indicate the saturation of the tissues. In the "poor risk" patient not frankly deficient in vitamin C, smaller doses (200 mg. of ascorbic acid daily) may suffice.

**Vitamin K**—Vitamin K should be administered (as menadione, 2 mg. intramuscularly) whenever the prothrombin level is diminished. The elimination of the hazard of postoperative bleeding in so many cases by this simple method is too well known to be mentioned further. In addition, as discussed later, an indication of liver function may be obtained from the response of the prothrombin level to the drug.

In summary, the preoperative and postoperative administration of vitamin C (500 to 1000 mg), thiamine (50 mg), riboflavin (10 mg) and nicotinic acid (100 mg) daily and vitamin K (2 mg) when indicated, is advisable in many surgical cases

#### CARDIAC ASPECTS

In considering surgical intervention in the cardiac patient, one must take into account the nature of the surgical procedure and the probable circulatory changes that may be induced by the operation. In many cases in which the surgical condition is one that threatens life—e.g., acute intestinal obstruction, unremitting gastrointestinal hemorrhage or acute appendicitis—there is usually no other choice but to operate. In cases in which immediate operation may, with relative safety, be slightly delayed—e.g., in carcinoma—time may be employed for improving the cardiac status.

One primary consideration in operations upon patients with organic changes in the cardiovascular system is *to avoid any marked fall in blood pressure*. From a review of the literature Woodbridge<sup>14</sup> states "It is generally agreed that coronary occlusion, angina pectoris, congestive failure and syphilitic aortitis carry high operative mortality and that valvular heart disease and auricular fibrillation or tachycardia do not add appreciably to the anesthetic or surgical risk."

It is generally held that little is to be gained by preoperative cardiac treatment except in the case of impending or frank congestive failure. The use of digitalis in any of its various forms and of diuretics (mercurial or theobromine derivatives) is too well known to warrant discussion here.

Patients in congestive heart failure who have healed or healing *cardiac infarcts* are extremely poor risks. Even in patients whose course following myocardial infarction has been satisfactory, it is said to require three months for a well-condensed scar to form and it may be months or years before the vascular collaterals develop to the point that the heart may function without symptoms. Ideally, one year should elapse before the patient with a cardiac infarct should be subjected to a surgical procedure. Presence of the anginal syndrome indicates coronary insufficiency and hypertension increases the load on an already damaged heart.

When operation must be done shortly after a cardiac infarct, the prognosis is grave. The procedure should be (1) as limited as possible to achieve its effect (e.g. cholecystostomy instead of cholecystectomy).

for acute gangrenous cholecystitis), (2) as rapidly performed as consistent with safety and (3) done under an anesthetic that is administered so as to provide the least possible chance of anoxia

In the postoperative period the administration of oxygen by nasal catheter face mask or tent is of great value and symptoms and signs of failure should not be awaited before instituting this therapy. Parenteral fluids must be administered cautiously. Blood and plasma if necessary, should be given slowly and in relatively small amounts to avoid overburdening of the circulation and the development of pulmonary edema. Two thousand cubic centimeters or less of fluid a day, in the absence of unusual fluid loss (e.g., vomiting, fistula or diarrhea) should suffice.

#### HEPATIC FUNCTION

The manifold duties of the liver as manufacturing center, storehouse and detoxifying agent make it one of the most important organs in the patient destined for operation. When the liver is damaged by toxemia or if its glycogen content is low, it is likely to suffer further from an anesthetic agent and operation. Preoperative determination of hepatic function should be made when possible in every poor risk patient. Since the liver reserve is so great that even moderate damage may not be detectable, the glycogen reserve should be bolstered by high carbohydrate diet or by the parenteral administration of glucose. In the presence of liver damage, the diet should be high in proteins and carbohydrates and low in fats and in addition yeast or choline (as the elixir, 5 cc three times a day) should be given. Of special value is the determination of the plasma prothrombin level and if low, its response to the administration of vitamin K. While an initially low level may indicate poor liver function or diminished intake or absorption of vitamin K, a significant rise after the administration of the vitamin demonstrates that the ability of the liver to manufacture prothrombin (and hence presumably to perform other functions) is not impaired and postoperative bleeding due to hypoprothrombinemia may be excluded. If the plasma prothrombin level is low initially (under 50 per cent of normal) and fails to respond to vitamin K, further impairment of liver function may be expected during and following operation. Other tests of liver function such as the cephalin flocculation and bromsulfalein test may be used. Important in protecting the liver against further injury is the administration of oxygen during the operative and postoperative periods.



## RENAL FUNCTION

The patient who is a "poor risk" because of renal dysfunction may suffer further impairment by the direct action of anesthetics and indirectly as the result of the operation and anesthetic. Urinary output may be diminished or arrested by ether anesthesia, and cyclopropane also diminishes the urine formation during its administration. Lowering of blood pressure during operation may so diminish glomerular filtration pressure that urine is not formed and with local anoxia there is damage to glomerular epithelium with the passage of albumin and blood.

The renal status should be determined preoperatively by a study of the ability of the kidneys to dilute and concentrate urine and to excrete phenolsulfonphthalein, and by determinations of the blood urea nitrogen. In the absence of cardiovascular contraindications, fluids should be forced to restore the blood urea toward normal.

In the outcome of operation in the patient with renal failure emphasis has been laid upon the importance of the chemical changes in the blood incidental to alterations in the acid base balance rather than water and nitrogen retention.<sup>9</sup>

## GASTROINTESTINAL ASPECTS

Especially important in the care of the "poor risk" surgical patient are attempts to prevent or combat *intestinal distention* (adynamic ileus). If severe, the distention may endanger anastomotic sites in the intestinal tract or the abdominal wall itself. Paralytic ileus may occur in the presence of general systemic disease such as pneumonia, sepsis and uremia. It may be associated with reflex changes in the autonomic system that may be produced by trauma (directly to abdominal viscera to ribs or central nervous system) or may be due to infection in or about the peritoneal cavity.

It was concluded by Wangenstein<sup>1</sup> that about "68 per cent of gas in the intestine in obstruction has its origin in swallowed air, 32 per cent forms within the body. About 70 per cent of the latter originated by diffusion of blood gases, especially nitrogen, into the bowel lumen, the remaining 30 per cent originated in the obstructed loop." Swallowing and gagging are common after inhalation anesthesia and there is increased swallowing of air. It is believed by some that spinal anesthesia reduces this difficulty.<sup>2</sup>

Dehydration, which is one of the first systemic manifestations of ileus, should be combated as indicated above. Not only is fluid lost during prolonged distention, but it has been shown that there is signifi-

cant loss in the volume of circulating plasma, and plasma volumes are partially restored following effective decompression.<sup>4</sup>

In the prevention and treatment of postoperative distention the use of an indwelling tube with continuous mild suction in the stomach or small intestine is of prime value. Routine use of a tube may add unnecessarily to the patient's discomfort, but in patients with peritonitis (due for example to ruptured appendix or perforated ulcer) or in those with resection of the small intestine, the decompressive action of the tube is of great value. The fluid and electrolyte lost through continuous suction must, of course, be replaced. In simple postoperative distention the tube may be dispensed with in thirty six to forty eight hours, while many days or even weeks may elapse before the tone is restored to the intestinal wall in cases of peritonitis.

Drugs are of value in the prevention and treatment of distention provided the ileus is of the adynamic variety. Morphine increases the tone of the small intestine but its prolonged use, particularly when administered with atropine, results in distention of the colon. Prostigmine 0.5 mg every four hours may be of prophylactic and therapeutic value by its apparent direct action on intestinal musculature.

The application of heat diminishes the motor activity of the intestine and relieves cramps. As previously indicated, the inhalation of high concentrations of oxygen reduces the volume of gas in the intestine.

#### RESPIRATORY ASPECTS

One of the greatest hazards associated with operation is anoxia. Permanent damage in the central nervous system may be produced by even a few minutes of severe anoxemia. A lowered vital capacity increases the operative risk and, as stated by Moersch,<sup>6</sup> the closer the vital capacity approaches the tidal air, the greater the risk. Anemia, with resultant lowered oxygen carrying capacity of the blood, may contribute to inadequate oxygenation of the tissues and should be combated preoperatively with *blood transfusions*.

Inability or refusal of the patient adequately to drain the upper bronchial tree may result in postoperative pulmonary complications such as atelectasis and pneumonia. *Suction bronchoscopy* is of value in obviating these complications.

*Sedatives*, as the opiates which depress the cough reflex, aggravate respiratory depression and predispose to pulmonary complications and are to be used with caution.

As previously indicated, *oxygen* has an important role in the post-

operative management of the "poor risk" patient. Of value not only in the treatment of shock and in preventing tissue anoxia in the patient with failing circulation, it is useful in the relief of gaseous distention and when mixed with helium may be respired with less effort than oxygen alone or oxygen and air.

The conspicuous reduction in the morbidity and mortality from postoperative pneumonia recently noted may be due, in great part, to the administration of *sulfonamide* drugs during the preoperative and postoperative periods. Whether this practice may become routine will depend upon future studies. Especially in the "poor risk" patient, vigilant watch must be maintained for the early signs and symptoms of toxic reaction to these drugs. Determination of the value of penicillin in this connection will have to await further data, but it promises much.

Improvement of intraoral hygienic conditions may aid in forestalling pulmonary complications as well as parotitis, which complication is favored by a dry mouth and poor intraoral hygiene frequently found in the "poor risk" patient.

**Anesthesia.**—While each "poor risk" patient must be considered individually in determining the choice of an anesthetic agent, certain generalizations may be made. Regional anesthesia with novocaine seems to possess the widest margin of safety. Of the inhalation anesthetics, cyclopropane and oxygen enjoys widespread use because of the high concentration of oxygen that is given and the low irritability. Ether is irritating to the respiratory tract and may predispose to pulmonary complications, vomiting, acidosis and hepatic dysfunction in some cases, but none the less is the anesthetic of choice in cardiac cases requiring general anesthesia. The anoxemia that may accompany nitrous oxide and oxygen anesthesia is deleterious. The toxicity of ethylene is low and better oxygenation may be obtained with it than with nitrous oxide.<sup>4</sup> In cases in which a fall of blood pressure is especially dangerous, spinal anesthesia is to be avoided. Pentothal and other intravenous agents are enjoying more widespread use in the "poor risk" patient and warrant wider study in this group of cases.

#### MOBILIZATION

It has been emphasized recently that prolonged periods of rest are anatomically, physiologically and psychologically unsound and unscientific.<sup>6</sup> The advantages of early mobilization of the elderly postoperative surgical patient have been recognized. In infants and children

immobilization is seldom attained in the postoperative period, yet complications are few

A collective review of the subject of early postoperative walking has been published recently.<sup>7</sup> Among the advantages of early mobilization are mentioned avoidance of asthenia, simplification of postoperative care, economy to hospital and patient and reduction of the incidence of pulmonary complications, thrombosis and embolism. The ever-annoying and often dangerous condition of decubitus can be avoided.

Obvious contraindications to early mobilization fall into two groups. In the first are cardiac failure, shock and severe anemia or cachexia, hemorrhage or the fear of hemorrhage, possible presence of thrombi or emboli and prolonged preoperative bed rest. In the second group are local conditions such as peritonitis, cholangitis, pancreatitis and liver infections, potentially infected wounds and copious tamponade.

The effect of early walking on wound healing and wound complications under present-day methods of wound closure and with the use of sulfonamides and penicillin remains to be established.

#### REMARKS

Great strides have been made in surgical technic during the past few decades, but the favorable results obtained, especially in the "poor risk" patient, are due in large part to better understanding of the pathological physiology of the ailing organism and the restoration and maintenance of functions as near normal as possible during the preoperative and postoperative periods.

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## PRINCIPLES OF SURGICAL AND THERAPEUTIC REFRIGERATION

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ALL life is conditioned to a comparatively narrow range of temperature, as regards both optimum function and survival. The variation upward is most limited and absolute, even the most thermophilic microorganisms withstand only comparatively slight temperature elevations, and plant and animal protoplasm is killed still more quickly and positively. The range of tolerance for reduced temperature is far wider, and in general the lethal effect is slow and there are more intermediate grades of injury. The formation of ice crystals or any other physical changes occurring at the critical point of cold are by no means as acutely or irreparably fatal as the coagulation of protein or death of enzymes which occur at the critical point of heat. Between the level at which function presumably stops and that at which death or irreversible changes occur, there is a zone of low temperature which is particularly wide for the lower organisms, but even in the highest species it contrasts decidedly with the abrupt limit of heat.

The effect of cold is also more subject to modification by other variables. Most important of these is the time factor, as will be illustrated. Next to this is hydration. The rate of cooling and also of rewarming is often important, and according to species and circumstances either a slow or a rapid change may be advantageous. Physical protoplasmic alterations have apparently their widest range in the primordial organisms, but in the high species there are so many variables of circulation, nutrition, position and other external and internal influences that the precise effects of simple temperature reduction cannot be established except under carefully standardized conditions.

It appears theoretically probable that life can persist at absolute

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zero judging by the intact survival of some primitive organisms at the lowest attainable temperatures within a few degrees of absolute zero. Spores are generally regarded as most resistant. The active forms of some but by no means all bacteria, protozoa and algae can withstand similar temperatures. It remains to be proved whether time is thus abolished, i.e. whether with absolute chemical standstill there is immortality at absolute zero. The speculation of Arrhenius that the first germs of life might have been carried to this planet from outer space through eons of time involves this question. For some organisms the time factor evidently remains potent at minimum temperatures for they withstand liquid hydrogen for minutes, days or weeks but not indefinitely. Some varieties are resistant whether wet or dry but the vegetative forms of bacteria furnish examples of great resistance in the dry form and death or attenuation by freezing or repeated freezing and thawing in liquid cultures. The importance of protoplasmic states is illustrated in the phenomenon of supercooling emphasized by Luvet and Gehenio: freezing slightly below zero Centigrade may be fatal but a rapid reduction a hundred or two hundred degrees lower may be nonfatal because there viscosity or other protoplasmic changes prevent freezing. It is of interest that some bacteria, molds and their enzymes can be active at several degrees below zero Centigrade. But the survivals from the cold of liquid gases must mean that life processes can resume spontaneously after being completely suspended and the recovery after radical refrigeration or brief freezing reveals this capacity also in mammalian and human tissues.

The general rule, subject to occasional exceptions, is that resistance to low temperature diminishes as animals and plants become more highly organized. Certain arthropods (tardigrades) are distinguished by their ability to withstand the temperature of liquid hydrogen in either a wet or a dry state. Contrary to folklore the common insects, frogs, fish and cold blooded species in general are killed by brief freezing. Some fish recover after being frozen stiff for a few minutes or even after immersion in liquid air for a few seconds because the time is insufficient for freezing of all the viscera especially the heart. Also various insects, amphibia and fish can tolerate temperatures a few degrees below zero Centigrade for considerably longer times because of their capacity for supercooling which prevents ice formation in their tissues. The functions of most cold blooded species run parallel with the temperature familiar examples being the torpid state and low metabolism of insects and frogs in a cold environment. The remark

able activity of various fish, such as the trout and salmon, in icy water must denote chemical and physiological processes adjusted to an exceptionally low temperature level. If there is any zone of reduced metabolism due to cold, or any "cold block" of their nerves, it must be at a lower level and within a narrower range than for most animals.

Observations and experiments on the hemoiotherms or warm blooded animals are most directly instructive for clinical medicine. Nevertheless the biological principles illustrated in the lowest organisms are found to hold good for the highest animals and man. Here it is convenient to consider separately the effects of cold upon the entire body and upon local parts.

### 1 SYSTEMIC HYPOTHERMIA

Without digressing into details of the voluntary and involuntary mechanisms for maintaining temperature, it may be noted that the increased heat production accomplished by muscular exercise and shivering is a defensive reaction against fall of temperature, not an actual result of reduced temperature in the cells. The metabolism of the hemoiotherms becomes specifically reduced in proportion as the temperature falls. This reduction is most extreme in the hibernators which retain the ability to react practically like poikilotherms. The slighter reduction of temperature, metabolism, respiration, heart rate and other functions demonstrated in nonhibernating animals and (especially by Fay and collaborators) in man is accompanied, incidentally, by a far smaller degree of insensitiveness to shock than has been described in true hibernation. The biological laws of hypothermia are illustrated as follows:

- 1 The fatal degree of cold is sharp and absolute. The death point ranges from  $13^{\circ}$  or  $14^{\circ}$  C in the rat to  $22^{\circ}$  C in the dog. Possibly electrocardiographic or other instrumental warnings of danger may be obtainable but simple clinical observation reveals no alarming changes as the rectal temperature progressively falls, until the breathing stops suddenly and the heart soon afterward. Rapid re-warming and ordinary artificial respiration are entirely unavailing to restore life. Fuhrman and Field's demonstration of the absence of an irreversible chemical change the ability of hibernators to recover from some conditions of chilling with artificial aid but not spontaneously, analogy with the general effects of cold, and the Russian experiences with revival of animals and persons after apparent death from other causes, all suggest that the suspension of vital processes may not be final if



some efficient means can be used to start them again. But the foregoing facts also indicate that the attempt to attain the extreme minimum of body temperature is a dangerous experiment, and Fay's record of about  $24^{\circ}\text{C}$  or  $74^{\circ}\text{F}$  probably represents the lowest rectal temperature that is feasible under the most skilled management in man.

2. The time factor is important for all temperatures above the acutely fatal point, and the limit of tolerance evidently varies inversely with the degree of reduction. Claude Bernard was the first to show that animals severely chilled for a number of hours become incapable of regaining normal temperature and die, with or without artificial warming. While Fay has continued "artificial hibernation" of patients for five to eight days, there is evidence that in both human beings and animals a relatively mild hypothermia of about  $90^{\circ}\text{F}$  can be tolerated longer or repeated oftener than more severe chilling.

**Clinical Uses.**—Therapeutically, the uses of cryotherapy for relieving intractable pain and reducing some fevers (especially those from central nervous injury) are well known. Fay's work together with our own put a stop to the previously universal practice of heating shocked patients. After disagreements concerning the advantages of normal or subnormal body temperatures, we interpret the weight of evidence as indicating that a slight fall of temperature is part of the spontaneous defensive reaction to uncomplicated shock, and that moderate cooling perhaps to the extent of  $96^{\circ}$  or  $94^{\circ}$  rectal temperature but not to the extent of causing discomfort or shivering is beneficial.

## II. LOCAL HYPOTHERMIA

The general biological determinants prevail in more marked degrees, because the temperature can be reduced to the lowest limits short of freezing and the tissues of warm-blooded animals can be reduced to the same minimal metabolism as the tissues of hibernators or poikilotherms. The therapeutic applications involve more details than can be covered within the present space limits, therefore rather frequent references must be made to other papers<sup>1-4</sup> which form a group with this one.

In contrast to the absolute limit of heat which can be tolerated and also the fixed limit of temperature reduction for the entire body, there is no known limit to the degree of cold which any local tissues can withstand. That the mere formation of ice crystals is not fatal is a fact made familiar by the brief freezing of ears or fingers in cold weather.

and the ethyl chloride method of local anesthesia. Although functional considerations forbid freezing of the entire heart or brain, the clearest demonstration of tissue tolerance is found in the experiments of Ebin, proving that large blood vessels (vena cava, femoral artery and vein) and the most delicate viscera (liver and brain) can be frozen with solid carbon dioxide for one minute without any microscopic changes perceptible weeks afterward. Mention is made of similar results with liquid gases, and the method is recommended for hemostasis in combination with cautery for liver and brain operations.

Except under special conditions, the time limit of safety stands in the usual inverse relation to degree of cold. Experimentally, tissues are killed in progressively shorter time by ordinary freezing, solid carbon dioxide and liquid air. There is therefore a biological basis for Davis's clinical contention that the frostbite of aviators at extremely low temperatures is more rapidly destructive than ordinary frostbite. Also injuries and necrosis can be caused by nonfreezing degrees of cold, if the time is sufficiently long and especially if harmful complicating factors are present.

The physical state of protoplasm is an important biological factor, as previously explained, because freezing is far more injurious than the same degree of cold without freezing. Lewis noted that the freezing point of blood serum is  $-0.53^{\circ}\text{C}$ , and the true freezing point of skin is somewhere near  $-1^{\circ}\text{C}$ . But skin rarely freezes at its true freezing point, because of its very marked attribute of supercooling. Freezing is unusual unless the surface temperature is reduced below  $-5^{\circ}\text{C}$ , and it may sometimes be reduced to  $-10^{\circ}$ ,  $-15^{\circ}$  or even  $-20^{\circ}$  without freezing.

Also, just as in the lower organisms, hydration plays a considerable part. The more water in the tissues, the more easily they freeze. Dryness of the outer skin layers is such an important safeguard against freezing that Arctic explorers are said to leave the skin unwashed for prophylaxis. Opinions differ regarding the benefit of rubbing with alcohol or oil. Wetness increases injury so markedly that lesions of the nature of "immersion foot" are well known at temperatures considerably above freezing.

Tissue damage is also increased by complicating factors, of external or internal origin. Among the external harmful agencies are friction of wind or water, immobilization, dependent position, constriction by clothing or anything else that hinders circulation, and especially pressure, which injures both by interference with blood supply and by

its direct harmfulness. Internal complications conducing to injury are local wounds, infections or circulatory abnormalities, and general functional or systemic circulatory disorders, malnutrition, avitaminosis, and all states of constitutional weakness.

Rational hypothermia therefore implies a selection of the factors which will be least injurious and most beneficial to a particular morbid condition. The uses of actual freezing for preservation or for selective destruction must be discussed elsewhere. Generally a division is made between radical refrigeration at temperatures slightly above freezing and milder hypothermia at considerably higher levels. The time may be as short as the three hours or less used for surgical anesthesia, or of intermediate or long duration for other purposes. Details of technique may vary to suit the respective needs.

One of the details which must be reserved for discussion elsewhere is the tourniquet, which introduces the complications of arrest of circulation, direct pressure, and special time limits and other conditions for the preservation of vitality. But though the maximum time limit has never been accurately established, it is known to be many times as long as the period of operative anesthesia. No recorded observations suggest injury from this short period of refrigeration, except the isolated study by Richards of only two cases which were too complicated to establish a scientific conclusion. The opinion that the briefly refrigerated tissues are injured so that they must be amputated is disproved by experiments, by our much larger experience with limb operations with and without amputation, and by the unanimous testimony of scores of surgeons concerning the favorable healing of wounds. The reasons why healing should be actually better than without refrigeration must also be discussed elsewhere.

**Clinical Uses.**—Prolonged hypothermia must be considered rationally in relation to its uses. It was proposed for certain major purposes such as the preservation of limbs seriously impaired in circulation or vitality, the temporary arrest of overwhelming infection or intoxication and the reduction of local metabolism so that the demands for oxygen and nutrition are brought within the capacity of a limited blood supply, thus preventing necrosis, infection, thrombosis and other accidents. As pointed out elsewhere<sup>3, 4</sup> the experiments of Brooks and Duncan have been universally misinterpreted. They confirmed the preservation of bloodless tissues during several days, but the pressure complication introduced in their experimental method resulted in far greater sclerosis at normal temperature than at reduced temperature.

thus illustrating the considerable protection against pressure injury which is furnished by cold. Their later experiments confirmed the arrest of infection and necrosis in small skin lesions, but they were therapeutically meaningless because of absence of any of the indications for refrigeration, such as lack of blood supply or resistance, and nobody has ever proposed retarding the healing of wounds for which the circulation and healing power are ample.

The errors of Large and Heinbecker have required notice<sup>3</sup> only because of the sponsorship of the Committee on Medical Research and the further postponement of long overdue recommendations for military adoption of refrigeration. They condemned brief refrigeration for anesthesia without a single experience with it experimentally or clinically. To the mistakes of Brooks and Duncan they added the complications of immobilization, dependency and soaking in ice water for forty eight to ninety six hours, and the resulting tissue injuries, though surprisingly slight, stand in contrast with the preservation of vitality and healing power with radical refrigeration (Crossman, Mock, Nachlas, Ottaway and Foote, and others) continued under proper therapeutic conditions as long as two to four weeks. The neglect of refrigeration during four years of war can be excused if the basic principles can be successfully attacked. The issue has been sharpened by the granting of public funds to inexperienced persons for the attempted attacks and the denial of aid to experienced workers for urgently needed theoretical and practical developments. Personal susceptibilities bear no weight in comparison with the decision whether this method can effect important savings of life and limb which are sacrificed by opposition and delay in the war emergency.

The attested benefits of refrigeration in civil surgery, which apply equally to military surgery, pertain to local infections and intoxications, embolism, thrombosis, emergency treatment of trauma, hemorrhage, shock, crush injury, prolonged preservation of limbs pending necessary deferment of operation,<sup>7 16 17 18 19</sup> orthopedic and plastic procedures, gas gangrene, frostbite or immersion foot, and burns.

*Refrigeration in Burns*—Further mention will be made only of burns because of their number and importance in war. Opportunities have been greatly needed for wider trials of proposed innovations, which include complete avoidance of the usual cleansing and debridement with their added tissue injury, the simplest dressings with thin gauze impregnated with bacteriostatic ointment or plain petrolatum, and hypothermia of such degree and duration as may be needed to

control pain, shock, infection and intoxication. Our favorable impression from our small series of published cases<sup>5</sup> has been subsequently strengthened, the management of one case by Kross<sup>8, 21</sup> being particularly notable. This case also illustrates a principle of rational hypothermia usually disregarded by critics. The temperature should be low enough for the required results, and in this instance the fever and intoxication returned whenever the skin temperature was allowed to rise higher than 60° or 70° F. At the same time the temperature should be kept as high as feasible, not for lack of proof that prolonged radical



Fig. 204—Before refrigeration treatment

refrigeration can be safe in cases where it is needed, but because healing is more rapid the higher the temperature, if complications are controlled. The period of eighty-nine days before this treatment could be discontinued is perhaps the longest hypothermia on record. It was completed without any of the bad effects which critics have feared. On the contrary, the radical refrigeration saved life in the first crisis of intoxication, and the subsequent milder hypothermia saved the leg for which amputation had seemed unavoidable. The accompanying pictures (Figs. 204, 205) support the contention that neither life nor limb could have been saved without the reduced temperature.

Refrigeration is being increasingly adopted by military and naval officers for critical wounds and burns, independently and with im-



Fig 205.—After refrigeration treatment.

proved apparatus. Regrettably, adoption seems farther advanced in a foreign army<sup>22</sup> than in our own army.

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## SYMPOSIUM ON REHABILITATION

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### FOREWORD

THE progress of medicine goes forward but we discover ever new problems. Our medical progress is both social and technical. We recognize social needs and we do everything in our power to meet them. Professionally we are continually seeking new ideas as to the cause of disease and trying to evolve from them sound principles and practices of treatment. Each case of disease may show a new way to health. In this march of medicine the present volume is another one of the forward steps.

At the present time medicine faces unusual problems. *C'est la guerre!* It is the war! The savage, barbaric, ruthless, gigantic world struggle for survival goes on. Millions of young men on five continents and the seven seas are fighting on land, in the air, on the seas and under the seas. There is the inevitable social reaction which creates new problems for doctors, psychiatrists and for the social workers. Families and homes are disrupted. Emotional and mental distresses increase greatly. Men and women are breaking physically, emotionally and mentally in alarming numbers. This creates the very great problem of war medicine and also the more numerous problems of medicine on the civilian front. Medical men, wherever they may be placed, are heroically meeting the challenge with new ideas, new principles and new practices to meet the old and the new needs.

War is a great teacher. It will teach the individual doctor much and advance the science and art of medicine greatly if we have but the wisdom to see and the will to learn. We must not neglect the will to learn. That we have it to some degree at least is indicated by the things that we have learned.

- (1) That the health and vigor of American youth has fallen short of military requirements in at least 5 000,000 of the registrants examined to date,
- (2) That an undue number of our youths of military age—1 800 000—are the victims of mental deficiency or disease and/or of nervous disorders,



- (3) That, in this country, illiteracy, emotional instability and psychoneuroses are much too prevalent,
- (4) That in addition to giving magnificent care to the troops military medicine has coped successfully with rehabilitation (1,500,000 men prior in May 1944) which represents perhaps the greatest rehabilitation job in history, and finally
- (5) That in the recovery of the war injured, certain physical mental and morale considerations are of the greatest importance in obtaining maximum medical and surgical results.

These facts should lead American medicine to take action to assume leadership in the national movement for the improvement of health and physical fitness, and for the improvement especially in the emotional stability and nervous stamina of many of our people. Furthermore, these facts lead us to seek more effective ways of dealing with 'disease en masse' and to utilize all the means at our disposal for the speeding up and perfecting the convalescence of the sick and the injured. They should lead us to seek and advocate the best ways to prevent, manage and cure disease, and the best ways to keep our people healthy, well and fit.

The present symposium is very timely indeed. The Medical and Surgical Clinics of North America are designed to keep the medical profession abreast of the times. This collection of papers presents the ways and means that surgery can be more effective in its remedial effects through the adoption of very important fundamental and basic principles. Outstanding authorities reveal the great possibilities of enhancing surgical results through each of the following: (1) physical medicine, (2) functional rehabilitation, (3) reeducation of the amputee for gainful livelihood, (4) rehabilitation of patients with head injuries, (5) actual physical reconstruction, (6) reconditioning and deconditioning and (7) the undesirable effects of undue bed rest. The principles enunciated and the practices recommended are real contributions to military surgery but they are also equally applicable to civil practice. This symposium therefore covers most admirably a wide range of the medical aspects of rehabilitation, the advances in our methods, and creates a better understanding of fundamental problems and the applicable principles.

If American medicine really learns the lessons that the war is now teaching and applies them in its daily practice then this war will have helped us save many human lives. Medicine will have learned much as to the ways and means of preventing and conquering disease and the

medical profession will be in a better position to counsel the Nation as to the prevention of disease and the ways of maintaining individual health and of attaining even higher standards of individual and public health. It is consoling to think that some great good for future generations will come out of the terrible death and destruction of this war and that medicine with its new insights and new methods will make possible a more abundant life for the American people.

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# FUNCTIONAL EDUCATION IN REHABILITATION

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THE six principal groups of the disabled needing rehabilitation are the blind and partially seeing, the deaf and hard of hearing, the cardiac, the tubercular, the neuropsychotic and those generally classified as orthopedic. The rehabilitation of the person with a so called one organ or special organ disability is not such a difficult problem because there is only one organ involved. The blind cannot see, the deaf cannot hear and the cardiac and tubercular need guidance on the amount of work they can perform. Rehabilitation is difficult in the neuritic and psychotic because of the influence of the mind on the body. The orthopedically disabled present the most difficult problem because of the variety of conditions which may occur. When one considers the hundreds of muscles, bones, ligaments and joints and the vast network of blood vessels and nerves supplying these structures the number of possible disabilities reaches astronomical figures.

If we accept the definition of rehabilitation proposed by the National Council on Rehabilitation as "the restoration of the handicapped to the fullest physical, mental, social, vocational and economic usefulness of which they are capable," then the methods of treating the orthopedically disabled have far surpassed those used in rehabilitation.

The purpose of this article is to review the present methods used in the rehabilitation of the orthopedically disabled and to present additional procedures which have been found successful.

## CLINICAL CONSIDERATION OF ORTHOPEDIC DISABILITIES

Orthopedic disabilities involve the range of motion at joints and the strength of muscles and result when congenital defects, trauma or disease affect the normal functioning of the bones, joints and muscles.

The purpose of treatment is to arrest the progress of the disease, prevent or correct deformities and restore the patient to the fullest physical, mental, social, vocational and economic usefulness of which he is capable.

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The present methods of medicine and surgery and occupational and physical therapy may restore 75 to 80 per cent of patients so they may be able to use their faculties normally, but these methods will fail in 20 to 25 per cent of the subjects. Every statistical study that we have conducted substantiates the reliability of these findings. Are we to accept these figures as the best that can be expected?

The Baruch Committee reported that "there is a gap between the customary end point of medical attention and the real necessities of many patients. In general, physicians have filled this gap in a lackadaisical and spotty manner, good here and there, indifferent in general. Rehabilitation fills this gap and provides maximal improvement for the patient."

It is evident from the report of the Baruch Committee and our experience at the Institute for the Crippled and Disabled, where we have been able to rehabilitate from 18 to 20 per cent of the severely disabled, that new methods are needed in our present rehabilitation program.

#### ESSENTIAL FACTORS IN REHABILITATION

What are the essential activities necessary to become physically, mentally, socially, vocationally and economically useful? We have found the essential activities to be (1) walking and traveling, (2) caring for daily needs and (3) using the hands in the performance of specific activities. Superior intelligence and skillful hands are of no vocational value unless the person is able to travel to a place of business to use his mind and hands. The one-armed man, without the assistance of anyone else, must learn to adjust his prosthesis, wash his one hand, clean his fingernails, tie his necktie and shoestrings, and perform the many activities inherent in daily living before he can be considered rehabilitated. These things will not be accomplished by surgical procedures or the application of heat, light, water or electricity.

#### A SURVEY OF PRESENT METHODS

What are the present methods used in many of our cities for the restoration of the handicapped to the fullest mental, social, vocational and economic usefulness of which they are capable?

In the great majority of cases the parents of handicapped children put on their prosthesis, and a special school bus transports them to a special school where special facilities and teachers care for their daily needs. At the end of the school day the teachers dress the children, the school buses return them to their homes and the parents care for

them until the next morning. This daily cycle continues until their public school education is completed or they are too old to continue in the grade school. When these disabled children leave school, they are homebound. They have never learned to travel alone, dress themselves or use the hands for specific work. These are the young people brought to us by their parents to be trained in a vocation. If the function of education is to prepare young people for life, it would seem that teaching the activities essential for living and working should be part of the school program. There is no commercial value for intelligence. It is only the use that is made of knowledge that is salable.

In the practice of medicine, as now being conducted in most hospitals, many patients with orthopedic disabilities are not rehabilitated to the maximum capacity to which they are capable. It is only natural for surgeons to be interested in surgical procedures and not the slow, laborious time-consuming methods necessary in rehabilitation. But the responsibility of the surgeon performing an amputation does not end with the healing of the wound. It includes postoperative care of the stump, advice in selection of a suitable prosthesis and supervision of the patient and the stump until both have become accustomed to its use.<sup>1,2</sup>

Most surgeons do not have the time, interest or training to carry out this assignment. The usual procedure is for the surgeon to delegate this phase of the postoperative care to the physical therapist or occupational therapist. This seems to be the proper place for the rehabilitation program. These technicians have the time and the interest, but it is questionable if their training is adequate to meet the needs of the seriously disabled.

The medical and surgical treatment of the injured of this war is saving the lives of thousands of soldiers who never would have survived in World War I. This will no doubt mean we will have more seriously disabled veterans. We must be prepared with a rehabilitation program which will restore them to the maximum degree of which they are capable.

#### PROCEDURES OF REHABILITATION

The rehabilitation of the seriously disabled is primarily a medical problem, but the assistance of the psychiatrist, psychologist, social worker and vocational guidance counsellor are necessary. Success depends upon the integration of all these services. Because of the limitation of space only the medical aspects of the procedures as used at the Institute will be discussed.

**Medical Examination**—The purpose of the medical examination is to evaluate the physical capacity of the prospective trainee in relation to his vocational training possibilities. The usual routine medical examination will discover the *cause, diagnosis and disability*. The next procedure is to measure the extent of the disability. Orthopedic conditions produce disabilities by limitation of movement at the joints and abnormalities in the strength of muscles. To evaluate the extent of the disability a *motor ability test* is used and when necessary a detailed *muscle test*. These tests give accurate information on joint movements, muscle power and coordination and are useful in prescribing treatment but are of little value in prognosticating the ability of a person to perform functional activities. The only method of discovering a subject's ability to perform an activity is to have him perform the activity. From a study of many plans of rehabilitation, it seems the present methods used in evaluating the physical capacity of a disabled person fail to realize this fact. The plan suggested by the Manpower Commission which is being used as the pattern for placement and replacement of the disabled person in industry, will serve to illustrate my point.

After seven years of research the War Manpower Commission published a book which gives an analysis of the physical demands of several thousand vocations.<sup>3</sup> The physical demands of the job are listed in terms of functional activities, such as walking, standing, pushing and lifting. Of the twenty-five activities listed, twenty of them depend upon the movements of the joints and strength of the muscles. Before a disabled person is placed on a job the physician decides which of these physical factors he has partial capacity or no capacity to perform. It is my firm conviction, based on the experience gained from examining thousands of orthopedically disabled, that to attempt to predict what physical activities can be performed by a disabled person on the basis of *inspection*, or even a *muscle test*, is unscientific and unfair to the disabled person. No one can predict with any degree of reliability the compensatory ability of a disabled person to perform functional activities until he tests the person in that activity.

**Gauging Ability to Meet the Physical Demands of Daily Life**—Another important factor, which seems to be taken for granted, is the ability of a disabled person to perform the activities necessary for daily living. Working in industry requires walking and traveling to the factory or industrial plant, caring for one's personal needs while at work and the ability to use the hands in performing simple everyday tasks. A

person with spastic hemiplegia can perform all the activities necessary to operate an elevator but it is important to know if he can get off and on a crowded bus or trolley car to come to work to button his pants and to adjust his clothing while at work and to write and answer the telephone. Every disabled person should be required to meet the physical demands of daily life as well as those of daily work.

Our test on the physical demands in daily life consists of thirty seven activities.<sup>4</sup> The person being tested travels around the testing area performing each activity as he progresses. He is given instruction on the activity to be tried and the need for the activity in daily living. The ability to cross a street on a green light is an essential activity and the following explanation is given the subject:

**Instructions to Subject:** When the green light at the end of the room goes on, step down from the curb and walk forward toward the opposite curb as if you were crossing the street. Try to get there before the green light goes off.

**Need for Activity:** Stepping down a curb and stepping up a curb are necessary daily activities since crossing a street involves these activities. In addition, these activities simulate the difficulties involved in stepping up and down steps when no railing or banisters are available. Such situations are constantly met in the steps which are often to be found in front of private houses.

Stepping down a curb, walking forty-eight feet and stepping up the opposite curb are necessary daily activities to be performed in sequence in order to be able to cross a street on a green light. It is highly desirable for any subject to be able to achieve these three activities in the time allotted rather than be obliged to start across the street on the red light or find himself in the middle of the street when the red light appears again.<sup>4</sup>

A grade is given for each activity and whenever desirable the time required is recorded. The symbols used are as follows:

N denotes that the activity is normal in methods used and length of time required to perform it.

\ denotes that the activity, though not normal, is adequate to present needs.

\X denotes that the activity, though not normal, is possible but very slow, labored or unsteady.

O denotes that the activity is impossible.

✓ denotes that the activity, not being normal, can be improved.

— denotes that testing the activity is not indicated.<sup>4</sup>

The important items to the medical examiner are those marked with the symbol "✓." It indicates that the subject can be taught these activities or improve his present performance. At the Institute, all the activities marked with the symbol "✓" are included in the trainee's daily program. While he is learning the trade which we have found best adapted to his interests, needs and mental and physical capacity, he is also being taught how to meet the physical demands of life. It takes six weeks to teach left hand writing while three weeks are often sufficient to learn to tie the shoe-laces with one hand. One trainee required ninety minutes to put on his braces and after three months of practice lowered this to sixteen minutes.

The same procedures we use in testing the subject's ability to meet the physical demands of living are used in evaluating his capability for the *physical demands of working*.

To summarize, the medical procedures which we have found successful in the rehabilitation of the severely disabled are as follows: (1) The Medical Examination to obtain the *cause, diagnosis, and disability*. (2) The Physical Examination, conducted by the physical therapist, to evaluate the *extent of the disability*, as measured by the motor ability or muscle test, and the effect of the disability upon the performance of the activities necessary to meet the physical demands of living and working.

#### FUNCTIONAL EDUCATION PROGRAMS

The testing procedures necessary to evaluate the medical and physical needs of the disabled are relatively simple and easy to perform. The methods used in teaching the functional activities inherent in daily living and working require careful planning and trained personnel. The most difficult subjects to rehabilitate are those with congenital cerebral palsy with spasticity or athetosis; older patients with acquired cerebral palsy with spastic hemiplegia;<sup>5</sup> those with spinal cord lesions with spastic or flaccid paraplegia, and those with thigh amputations of both extremities.

The plan of functional education which we have found most successful is first to evaluate the disability and then outline the program in a logical sequence. There are three points to the program: (1) the fundamental activities, (2) the skill activities indoors and (3) the outdoor activities. The procedures used in a rehabilitation program for a subject with spastic paraplegia resulting from transverse myelitis will illustrate how the program functions.



1 The subject is measured for the type of braces best suited needs<sup>6</sup>

2 While the braces are being made, special exercises are given the man or in a wheelchair to obtain flexibility so that he may be able to bend and reach in all directions to the maximum extent. A flexible body is necessary to perform the demands of daily living, such as putting on socks, shoes and braces.

3 Exercises are given to strengthen the muscles of the shoulder girdle, extensors of the forearm, flexors of the fingers and the abdominal and extensors of the legs. The ability to walk with crutches depends upon the strength of these muscles, especially the extensors of the forearm.<sup>7</sup>

4 When the braces are fitted, the subject is measured for crutch and crutch exercises for balance and walking are started.<sup>8</sup>

5 Each subject is then taught the various crutch gaits, and the best suited to his disability and skill are selected for his use.

After he has successfully completed the fundamental activities, then started on the skill activities required to meet the physical demands of living and walking. They consist of traveling up and down curbs, steps, in and out of buses, developing speed in crutch walking so as to cross streets on the traffic lights, falling and getting up and taking off and putting on braces, getting in and out of bed and different types of chairs and many other activities of a similar nature.

After these activities have been successfully learned in the treatment room, the subject is ready for the final outdoor practice. The technician accompanies him outdoors and he then performs all the activities in situations which occur in daily living.

No one can comprehend the mental and physical strain endured by a disabled person who has been in a wheelchair for nineteen years when he wants to cross a busy street when the light turns green. It is just as difficult to imagine the joy of accomplishment.<sup>9</sup>

### CONCLUSION

The purpose of the rehabilitation program for the seriously disabled is to restore them to the maximum physical, mental, social, vocational and economic capacity so they may be able to meet the demands of daily living and working. To accomplish these objectives it is necessary to develop testing procedures to evaluate the extent of the disability and the needs of the subject and to formulate functional educational programs to meet these needs.

It is essential at this crucial period when so many of our young men will be disabled in the war that we develop rehabilitation methods equal to our surgical skill. Of what use is it to save the body if it cannot function mentally, socially or vocationally in the world in which it lives.

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## REHABILITATION OF THE AMPUTEE FOR GAINFUL LIVELIHOOD

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THE physician has always been interested in the total welfare of his patient, in his physical and mental and social and vocational relationships, but his interest has always been conditioned by the word "cure." That word once meant relief from symptoms and the restoration of working capacity and social living. Thus, too, is the aim of rehabilitation. The two terms are therefore largely synonymous. The treatment of a fracture, or pneumonia, or low back pain, or any other injury or disease entity has as its goal the restoration of the individual to his former pre-illness status. But these accidents and illnesses fall into the category of temporary incapacities. Normal working capacity is anticipated after the relief of symptoms and the restoration of function. Return to duty is the goal arrived at in military service. It is expedited by programs of physical conditioning and convalescent training, occupational therapy and other methods for the development of the physical powers of the individual. The aims are always the same: return to duty or return to work.

There is another category of patients in which restoration of the pre-illness or pre-injury status is not obtained by medical and surgical treatment. Exhaustion of the resources of treatment does not always bring about return of working capacity. The man who has lost his arm by amputation can no longer return to his job in an orchestra. The above-the-knee amputee can rarely climb a ladder or perform the necessary functions that would permit him to return to his former job as longshoreman. While the majority of those who have suffered a below-the-knee amputation can return to their former occupation, many are nevertheless required to change to more sedentary operations in the same field in which they were previously engaged.

For those who suffer permanent disabilities, medical and surgical measures must now be supplemented by other methods to achieve restoration of working capacity. Vocational guidance and training and selective placement by matching the physical demands of the job

to the physical capacities of the individual must now be added to the armamentarium of the physician.

It is not expected that the physician can become overnight an expert counselor or an experienced placement officer. These activities must be left to those who are qualified in these fields. The physician, however, must have some understanding of the principles involved and the objectives aimed at. These principles can be briefly epitomized under three broad objectives: (1) physical restoration, (2) vocational guidance and training, and (3) suitable employment.

#### PHYSICAL RESTORATION

Certainly there will be no disagreement concerning the physician's responsibility in the surgical management of an amputation. While the indications for amputation are fairly well understood, the sites of amputation have not always been determined by the surgeon. The artificial limb manufacturer has in large measure conditioned the whole field of amputation surgery. Difficulty in the manufacture of certain types of prosthesis has frequently caused condemnation of certain sites of amputation. More important is the influence on the surgery of amputations from the traditional days before modern surgery and modern prosthesis. Then the peg leg was the best that the amputee could expect to obtain and the surgical desideratum was a stump that could withstand weight bearing. This meant that the stump had to be thoroughly cushioned against this trauma. Terminal scars had to be avoided, hence markedly unequal flaps had to be prepared. The bone had to be carefully cushioned by muscle flaps.

With the advance of modern prosthesis, the weight shifted from the end of the stump to either side-bearing or ischial-bearing. Surgery of primary flap amputations has been simplified. Markedly unequal flaps are no longer necessary, hence long flaps with the danger of necrosis can be avoided. Shorter flaps are adequate, while terminal scars can be made with impunity except in end-bearing stumps as in the Syme's amputation and Stokes-Gritti amputation. Muscle flaps are no longer necessary. Instead, the skin and subcutaneous fat and fascia are adequate covering for the transected bone and muscle. Nerves are not injected but strict attention must be paid to hemostasis. These simple rules are the basis for the satisfactory surgical management of amputations where the danger of infection is not present.

In the presence of active or threatened infection, closure of the amputation by closed flaps is not desirable. The experience of military

surgeons is replete with examples of flaps breaking down, requiring reamputation with additional bone loss. Today complete primary closure of amputations is rarely practiced in the field. The types of amputation substituted are those of the guillotine or modified flap amputation. The procedure is now provisional and hence presupposes revision with closed flaps at a later date.

**Guillotine Amputation.**—There is still considerable confusion concerning the indications for and the value of guillotine amputations. As the name implies it means a complete transection of all the tissues, skin, muscle and bone in one plane. Thus a wide area is provided, sufficient to drain a frank or threatened infection.

The disadvantage of this type of mutilating procedure is the extent of the healing period. Months are required before the large wound begins to heal, permitting revision and secondary operation. This time can be shortened by the immediate application of skin traction by adhesive strips or stockinette impregnated with adherent glues or plastic material. The early application of skin grafting can also help to shorten the healing period. The additional advantage of the latter procedure is the quick relief of pain and the improvement in the patient's general condition.

When the guillotine amputation has been made at or close to an elective site such as a point 5 to 5½ inches below the knee, skin traction is imperative to provide adequate skin coverage for the end of the stump (Fig. 206). The long period of wound healing taxes the patience of the surgeon so that he will not wait for complete healing and will frequently revise even in the presence of a granulating wound depending on the sulfonamides or penicillin to bring him safely through. This procedure in healthy young boys is practical but minor complications in the way of incision breakdown postoperatively or upon wearing prosthesis reveal the feeble character of the healing that remains.

The classic guillotine amputation therefore, is an unsatisfactory procedure because of the long healing period and especially since the general practice has been to sacrifice bone length unnecessarily because of confusion about the site of amputation. There is one situation where it is not only desirable but mandatory and that is in cases of fulminating malignant and rapidly spreading gas gangrene. Certainly a bacteriologic diagnosis of gas bacillus infection is no reason for performing amputation. Muscle excision may frequently provide satisfactory removal of the focus of infection and adequate drainage. The

clinical picture of severe shock, rapid thin pulse and high temperatures ( $104^{\circ}$ – $105^{\circ}$  F) is a more important criterion in determining the diagnosis

In the absence of gas bacillus infection, guillotine amputation is therefore, neither necessary nor desirable. Drainage is nevertheless required in the presence of infection but this can be obtained by a modified procedure. Flaps are made as in clean primary cases. The muscles are transected as in the guillotine but the flaps are secured in the center over the bone with one or two sutures. The open wound at the



Fig 206

A

Fig 207

B

Fig 206—Guillotine amputation stump after six weeks of skin traction by means of Ace adherent and stockinette

Fig 207—A, Syme's amputation with prosthesis open B, Syme's amputation with prosthesis closed

sides of the partially sutured flaps provides sufficient drainage for the ordinary cases of infection. In military practice, suturing the flaps is never permissible, but the presence of the flaps with the aid of skin traction expedites the coverage of skin over the bone and shortens wound healing. Revision following this practice becomes a minor procedure of simple excision of the healed scar, whereas the ordinary guillotine wound requires an excessive excision of scar and skin and a wide undermining of skin and subcutaneous tissue. This is so extensive that the procedure is indeed a major surgical operation with its attendant risks. Furthermore, the inability to pull the skin over the bone

necessitates the removal of bone. Thus the minor revision is in reality a reamputation.

**Final Amputation**—The rehabilitation of the amputee begins with the decision of the surgeon to amputate. On the site and character of the incision will depend in large measure, the future of the individual. The guillotine amputation or the modified flap amputation is only a provisional procedure. The end sought by the secondary operation or the original primary flap amputation is a stump that will properly carry the patient's weight and permit him to wear and use a prosthesis with comfort and utility.

In the lower extremity, four types of amputations have been accepted as standard procedures. Syme's amputation, the below the knee amputation, the Stokes Gritti amputation and the midhigh amputation. While modifications of these types of amputations may be indicated under special conditions, these standard sites and types will meet the demand of the average case.

**Syme's Amputation**—This type of amputation should be used for any injury to the foot in which the loss of tissue is proximal to the metatarsotarsal joints. The loss of this latter joint makes weight bearing difficult and intermediate amputations attempting to save the tissue of the foot prove unsatisfactory, disabling and time-consuming requiring repeated amputations with resulting economic disability.

At operation the lower leg is transected through both malleoli at about  $\frac{1}{4}$  to  $\frac{1}{8}$  inch above the articular surface of the tibia at the ankle joint. The skin of the heel after enucleation of the os calcis is used as a skin flap to cover the bone, providing a skin surface that can resist all the usual demands of weight bearing. The stump can be used without a prosthesis for weight bearing in an emergency.

The objections to this amputation are, first, that it should not be performed in the presence of infection, for unless the wound heals by primary intention the amputee cannot be properly fitted. Secondly the prosthesis is somewhat bulky at the ankle (Fig. 207) and hence not appropriate for a woman for whom esthetic considerations are no mean factor.

**Below-the Knee Amputation**—The optimum site of amputation is  $5\frac{1}{2}$  inches below the knee joint line. Stumps of 2 to 3 inches can also be effectively utilized especially if most of the muscles clothing the tibia and fibula are removed, leaving a stump essentially of skin and bones.

In the standard operation at the optimum site, the muscle is cut at an angle of 35 degrees to secure a sloping but not too conical stump. The fibula is cut 1 inch shorter than the tibia, which is beveled on its anterior crest. The fibula is rarely removed except for a severe flexion contracture at the knee. The nerves are not pulled down or injected and the bone is covered not by muscle flaps but by skin flaps. The latter are not made long, since long lateral incisions interfere with skin circulation and favor necrosis.



Fig 208



Fig 209



Fig 210

Fig 208—Ideal stump for below knee amputation

Fig 209—Short yet useful stump for below knee amputation

Fig 210—Plastic leg covered with leather for below knee amputation

The resulting stump (Figs 208, 209) is satisfactory for the routine pursuits of life. Weight is not borne on the end of the stump but on certain weight-bearing points—the condyle of the tibia, the head of the fibula and the tibial tubercle. If the artificial limb is fitted properly, these pressure bearing areas will carry the weight evenly distributed. When the weight is improperly distributed, excessive weight falls upon one of these points causing skin irritation and pressure sores and inability to wear the prosthesis. Accuracy of limb fitting avoids this complication. Where excessive weight bearing is required, the limb



maker can so distribute the weight bearing strain to other parts of thigh and ischium as to relieve the amputee from the pain and comfort of excess local pressure on weight bearing points (210)

The knee mechanism is so valuable that the future of the amputee rests on the decision to retain it. The man who has lost his leg below the knee is rarely handicapped. He can resume his former occupa-

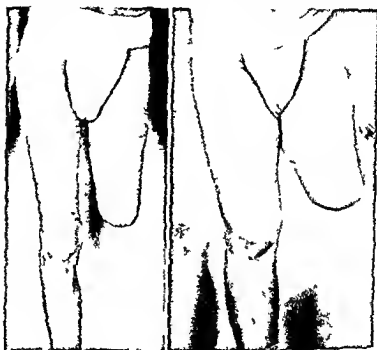


Fig 211

Fig 212

Fig 211—Stokes Gritti amputation

Fig 212—Amputation at the junction of the lower third of thigh

or follow a large variety of vocations similar to it. The man who has lost his leg above the knee is usually restricted in his activity.

**Stokes Gritti Amputation**—This amputation provides a weight bearing stump which can withstand excessive demands (Fig 211). It is a type of amputation favored by the Canadians even over the below the knee amputations because of its ability to endure prolonged and excessive weight bearing.

The operation aims to utilize the cut patella fused to the cut end of the femur at or about the level of the adductor tubercle. In rare cases

the flaps in this operation, the skin and muscle flaps should be made as one providing adequate circulation to the flap and avoiding skin necrosis

**The Above the Knee Amputation**—The above-the-knee amputation should measure 11 inches from the top of the trochanter to the end of the femur (Fig 212) Inasmuch as the adductor muscles are inserted all the way down the shaft of the femur, the stump must be long enough to retain sufficient adductor power The loss of every inch of femur renders the muscular control of the hip more difficult

When the stump is too short to remain inside the socket during movement at the hip, the amputee has to wear a tilting table limb The ability to fit a short stump to the ordinary above-the-knee limb depends upon the amount of the subcutaneous tissues But even when a tilting table is inevitable, the limb maker likes 4 inches of femur left, measured from the top of the great trochanter A disarticulation at the hip joint is unsatisfactory for limb fitting

**After-care**—The surgeon's work is not completed at the end of the operation Two further duties remain to be performed He must prepare the stump to receive a prosthesis and he must teach the patient how to use his prosthesis

Preparation of the stump implies the shrinking of the stump This means that the shape of the stump must be changed from a wide cylinder to a narrow cone This can be done by the compression obtained by tight bandaging or by the wearing of a pylon Bandaging has the advantage that it can be started early, long before the stump can tolerate a pylon The Ace elastic bandage must be applied under the greatest possible tension and this is facilitated by rolling the bandage tightly before applying it The greatest tension is applied to the end of the stump, otherwise the stump becomes bulbous instead of conical The bandage must be reapplied several times daily for it loses its effectiveness if it does not remain taut Wide bandages are used to secure these results The objective is to obtain below the knee a stump that is practically skin and bone This is a goal that cannot be achieved in the thigh stump Nevertheless, an intensive program of bandaging four times a day followed rigidly for three weeks will secure sufficient shrinkage for the application of a permanent prosthesis This goal is rarely reached without close scrutiny and supervision The patient is apt to view the shrinking process with apathy while the surgeon concentrates on the surgery and not on the after care Much time is lost at this crucial point because there can be no compromise

It is an all out effort or a failure. The application of a permanent prosthesis to an inadequately shrunk stump requires remaking of many sockets with disgust, disappointment and frequent loss of time for the patient.

The pylon has the great psychological advantage of convincing the patient that he can walk. He thus dispenses with his crutches early. He is stimulated and exhilarated by the knowledge that he is not handicapped. However, in the attempt to effect this step early the green stump finds itself unable to withstand the trauma of weight bearing. The formation of painful neuromas, the ulceration of the skin and scar testify to the premature stress to which the stump has been subjected. Frequently, improper alignment of the pylon teaches the patient unfavorable habits of balance and weight bearing which interfere with his adjustment to his final and permanent limb.

Massage of the stump is contraindicated. The freshly cut nerves are too tender to withstand the trauma of manipulation and manual pressure except for overcoming contractures. All other forms of physical therapy have no specific place in the after care of amputation stumps with the exception of exercise. These exercises are not necessary in below the knee amputations. They are required in above the knee amputations, especially in short thigh stumps. The loss of the lower attachment of the adductor muscles causes overaction of the abductor. Development of the adductors and extensors of the hip are definitely indicated in order to control the action of the prosthesis. The loss of the knee mechanism puts a double load on the hip extensors—that of extending the hip and extending the artificial knee.

Many artificial appliances such as teeth and eyeglasses require no special instruction in their use. The below the knee artificial limb properly falls into the same class. The average amputee takes to it like a duck to water.

The above the knee amputee does require special instruction in the use of his prosthesis. This instruction emphasizes the function of balance. Normally, balance is maintained by the foot muscles but since these are gone, the amputee must now depend on the vicarious function of the hip muscles. Rarely does the amputee receive such training. Here again, as in binding and shrinking, he is deserted by the surgeon. But he is also deserted by the limb maker who considers his job completed when he fits the limb. Thus the amputee has to learn how to walk the way he learned to skate—by falling down a number of times. The limb maker cannot be expected to know the mechanics of

walking Someone, therefore, who is competent and interested must be delegated to carry out this responsibility

Difficulties in the adjustment of the amputee to his arm prosthesis are the result of failure to give him the instruction immediately after the application of the apparatus. He soon becomes impatient with his temporary inability to manage and assumes that his whole future will be like that. He will, therefore, discard the prosthesis as more trouble than it is worth unless he is trained to use it. That training is more difficult than in the case of the lower extremity because the scapular muscles have to take on the function of the finger muscles.

**Prostheses—Lower Extremity**—When the stump is shrunk by bandaging or pylon, the leg is then ready for a permanent prosthesis. What kind of prosthesis shall it be—wood, metal, fiber or plastic? These are the questions facing the civilian amputee. The claims of rival concerns regarding the durability, comfort and utility of their respective materials is further clouded by the special devices in joints, double-acting knees, special locks and so on. The surgeon in the past has been in no position to referee the fight between rival concerns. Controversy will continue, no doubt, on the relative merits of the various materials and devices. Regardless of the type of material the one most important criterion of value is that of *fit*. Unless the limb fits the stump perfectly, it is of no value. There are many limb makers who can make excellent looking and durable limbs yet who lack the artistic ability to make the limb fit the stump. Limb making and limb fitting are not the same. The English have recognized the importance of this special ability and have developed a new type of hybrid professional, the limb fitting surgeon as a go between for the limb maker and the limb fitter. Alignment, the placing of joints, the relationship of the foot to shank, the knee to the thigh, types of joints, the need for locks—all are important factors in the art of limb fitting.

The next consideration is that of *weight*. Because of its comparative lightness, wood (willow, poplar) has been the universally accepted material. Duraluminum, fiber, leather and plastic have challenged the supremacy of wood but have not yet displaced it. The use of plastic, however, because of its ease in manufacture is the most serious challenge it has had to face.

In the above the knee amputations, the loss of the knee mechanism requires a complete physiological reorientation. Weight is now a real consideration and metal is in general preferable because of this fact.

Other factors such as durability and response to perspiration (as in

leather) must be considered. But the primary consideration is the character of fit.

The amputee must also be instructed not only in the use of his artificial limb but in its limitations. The ankle joint should not be expected to give unusual motion. A below-the-knee apparatus should be

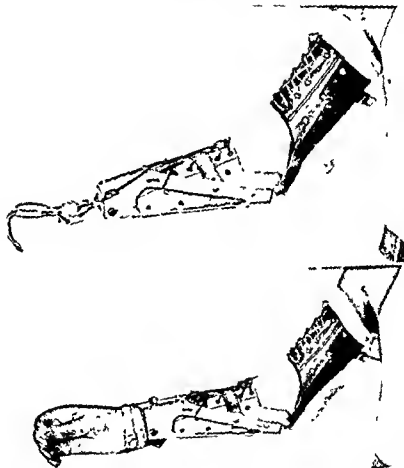


Fig. 213—*Above*, Mechanical arm with hook attachment operated by cords attached to opposite shoulder. *Below*, Mechanical arm with interchangeable hand.

simple. A high thigh amputation should be given the assistance of a double-acting knee or a gravity lock. A pelvic belt replaces the old-fashioned harness and a brake at the knee replaces the control cords of old.

**Prosthesis—Upper Extremity (Figs. 213, 214)**—The loss of the lower

extremity can be easily compensated for by artificial means because the function lost that of weight bearing can be easily reproduced. When a man loses his hand or arm he loses the function of prehension or grasp which cannot be reproduced. It can only be imitated. Hence the arm amputee makes a less satisfactory adjustment to his prosthesis than the leg amputee. In the first place he soon learns that for the active pursuits of life he can get along very well with his remaining sound arm. He learns that we are all essentially one handed and that less than 15 per cent of our normal activity requires bilateral grasping function. There are many double arm amputees who can get



Fig 214.—Cineplastic prosthesis. Hand manipulated directly by muscles remaining in the stump

along without prosthesis using the approximation of their two stumps for prehension. Others use simple devices such as a leather strap around the end of the stump into which various articles of daily use (eg. toothbrush razor) can be placed. But for the majority an artificial arm is of distinct help in caring for their needs. Furthermore by filling the empty sleeve the defect is camouflaged against the truculent public prejudice toward the deformed and limbless. But what kind of an appliance shall we prescribe. Shall it be the clever mechanical hand demonstrated by the salesman from X Company? You may be disappointed when you try to use it because you can never equal the artistic achievement resulting from his twenty six years of practice

Shall it be a hook or other simple device? Shall it be a special surgical tool like the Krukenberg or cineplastic?

The decision that is made must be one in which the character of the stump is only a secondary consideration. The prosthesis is not to be fitted to the stump but to the patient's whole personality. On his background, experience and interests, his hopes, aims and aspirations will the proper choice be made. If he plans to do heavy work, a work arm of the hook type is desirable. If he hopes to meet the public a cosmetic arm or a cineplastic arm will be satisfactory.

*The ultimate aim of rehabilitation is the social adjustment of the amputee through the development of his mental and physical powers so that he can become self-supporting and self-sufficient.* In the realization of this aim, he must fulfill two requirements: (1) he must meet the requirements of daily living, and (2) he must meet the requirements of employment. Proper fit and instruction in the use of his prosthesis will satisfy the needs of daily living. Work adjustment is a problem which requires a more discriminating analysis and understanding.

#### VOCATIONAL GUIDANCE AND TRAINING

Vocational guidance, orientation and training can be undertaken only after an evaluation of the patient's total equipment, mental as well as physical. An appraisal of the patient's capacities and abilities, his interests and aspirations, can be obtained by observation, by interviews, and by aptitude testing. Only in a small number of cases is the last procedure required. When undertaken, the test results are of little value when they are either very high or very low. In the former instance it would indicate an unusual capacity predicting successful achievement. A low score would indicate failure. For the majority those falling between the two extremes, test results are of little value. They are not indices of the patient's total personality or powers. Emotional motivation frequently compensates for poor innate abilities, while training can produce a good performance even with mediocre material. The day of the fortune teller and phrenologist is over. No one can predict human behavior. We find that the average man can do the average job. He will make many false starts if he is unskilled until through exploration he finds his proper niche. A few will end up in frustration and blind alley jobs. Those who have well organized personalities will follow their life pattern uninfluenced by the rigors of the day to day living until they have reached that goal, the seed of

which has been planted early in life because of identification with a powerful influence, be it individual or situation

Fig 215



Fig 216



Fig 217

Fig 215—Under the supervision of competent instructors, the amputee learns the operation of the standard tools in a machine shop

Fig 216—The partial hand amputee can operate a drill press with very little adjustment

Fig 217—This double thigh amputee tries his hand at gem cutting. A veteran of the South Pacific, he has suffered the amputation of both legs just below the hips

There will be those who will be overwhelmed by their disabilities and there will be others who will be stimulated to greater achievements



The majority will make satisfactory adjustments. The ability to make this adjustment will depend on many factors such as emotional stability, strong vocational interest and opportunities to develop their interests by education and work training. The improvement of mental powers through education on the grade school, high school and college levels and commercial or trade training may not always produce immediate or tangible results. But the advantages are none the less clear. For those in military service, especially in the younger age group it



Fig 218



Fig 219

Fig 218—This amputee has found his niche doing precision work on a lathe turning out 155 mm howitzers in a nearby plant

Fig 219—The use of the hook prostheses in the operation of a gem cutting machine is illustrated by this amputee. A leg gone amputation of the right arm below the hook by shrugging the opposite shoulder a strap

gives them an opportunity to complete credits toward a high school diploma or college credits which help them to qualify for certain jobs requiring college credits.

Trade training takes many physically handicapped persons out of the unskilled into the skilled class with greater economic return and personal satisfaction. For the amputee disabled in military service work training has many values. Trained to be a fighter, he has sloughed off many of the controls and influences which make for good industrial workers and good citizens. Through work training he re-

learns those homely yet important industrial virtues such as punctuality, respect for property, the value of a dollar. Work training provides him also with a laboratory to test out his vocational interests. He learns to transfer the loyalties toward buddies, chiefs and sergeants of his combat unit to the industrial unit of which he becomes a part. His fellow-workers now become his buddies, the foreman and the supervisors must now take the place of the sergeants and the chiefs.

### RECAPITULATION

The processing of an amputee from admission to discharge takes the following course. Evacuated from the South Pacific by air or ship, the patient is brought to the hospital for the completion of the surgical management of his amputation stump. By skin traction, special bandaging, plastic repair and revision depending upon individual requirements, the stump is brought to that final state which will make it fit an artificial leg with the maximum of comfort and utility and the minimum of adjustment.

As soon as possible and even before the final stages of wound healing, the patient is urged to get out of bed. Long bed care only intensifies depression and anxiety. He is then placed in exercise classes. At first, simple setting up exercises are given at stated intervals for general body conditioning. Special exercises for above-the-knee stumps are also administered. He is urged to participate in sports. Special swimming classes are organized as well as tennis and badminton if he has lost an arm.

As soon as the stump is sufficiently conditioned, sometimes within four to six weeks after operation, a temporary prosthesis is applied. This is made of a permanent foot and regular ankle and knee joints, and plaster-of-paris buckets. These plaster buckets into which the stump fits can easily be changed as the stump shrinks. Occasionally the permanent leg can be applied without an intermediary temporary prosthesis.

During this period the patient learns to walk and balance himself. He toughens his stump to meet the demands of weight bearing. At the same time the stump shrinks thoroughly and reaches that relatively final state when a permanent prosthesis can be applied. When this state is reached, he is conditioned to use the prosthesis for work demands for a full day and for all social activities such as dancing. When he is discharged, the patient has a fine looking custom-made leg prepared to meet all the demands of civilian life.

In the early days of hospitalization, while the patient was in bed recovering from surgical procedures, a limited program of occupational therapy was made available to him. Leather work, fly tying, knotting, the care of miniature gardens, finger painting, carving airplane models—are a few of the activities in which he is encouraged to participate. These activities help to immunize him against the virus of "hospitalitis" with its indolence, procrastination, and lack of ambition. The stimulation of interest by leather work, whittling, or lapidary work are stepping stones to interest in correspondence courses or a self-help course in Diesel engines. The patient is thus prepared for the services of the Educational Services Officer who will spend considerable time discussing plans for his future.

When the patient is ambulatory, an opportunity is made available for more intensive counseling. The patient's whole background is spotlighted and all the facets of his personality are explored. This requires not only technical competence on the part of the counsellor but definite rapport with the patient without which the efforts of the Educational Service Officer are wasted. Personal magnetism will frequently compensate for even limited technical ability in this field. The patient must sense the vital interest felt in his welfare.

In helping patients arrive at satisfactory vocational objectives it may be necessary to avail ourselves of detailed psychological analysis by interviews, observation and special tests. Some wish to go into the fields of law, dentistry, ballistics, radio, welding, electricity, farming, and metallurgy. Some plan to work as machinists, veterinarians, grain and feed buyers, and so on. Representatives of the State Rehabilitation, Red Cross social service, and the United States Employment Service are also consulted for advice and counsel. Special cases are reviewed at weekly conferences by the entire rehabilitation staff.

The choice of the training program must meet with the full approval of the patient. It is he who makes the selection with the assistance and guidance of the staff.

Training must take into consideration the period of the hospital stay and the necessity for frequent interruptions for surgery and limb fitting. It can be confined to self-help courses and tutorial courses given on the Compound. Courses on the grade school level, high school level and university level are also available. Some of these courses are given in the hospital, others at nearby institutions.

J.M., Seaman Second Class, had an amputation of the four fingers of his right hand. He was interested in a career in medicine and showed that he was qualified on the basis of his past educational performance and by his high rating on an intelligence test. He was sent to a nearby Junior College to commence his premedical courses and to make up high school deficiencies.

W.C., Seaman First Class, with a right below the knee amputation, wished to become a watch repairman. Through the California State Rehabilitation Bureau we arranged for him to try his skill at this trade. He found he had neither the basic dexterity nor the inclination to carry on this type of work. We finally found the type of work he desired with the Tennessee Eastman Corporation. This man made his mistakes while in the hospital and escaped the frustration of these false steps after discharge where they would have been more costly.

T.H., Private First Class, with an amputation of the right leg above the knee from wounds received at Cape Gloucester, was an apprentice lens grinder before entering the service, having completed one year of apprenticeship. Arrangements were made for him to continue lens grinding and to work off more apprenticeship time while convalescing.

C.W., Private First Class, a paratrooper, lost his right leg above the knee at Bougainville. He had completed one year of college preparation for forestry but had failed in chemistry. He was sent to a nearby Junior College where he not only made up his year of chemistry but is continuing his college work while his convalescence progresses.

E.H., Corporal, was attending school when he enlisted in the Marine Corps in February 1941. Gunshot injuries caused the loss of the use of his right arm. Machine shop training and mechanical drawing are the preliminary steps he is taking to enter a university after the termination of his service.

#### PLACEMENT

Work training projects are designed for two purposes. In the first place, the over all training serves as a preliminary field of exploration from which the selection of a permanent vocation may be realized. It is more important that the patient should avoid frequent changes of jobs after his discharge. He can make these changes while he is still a patient in the hospital without severe consequences in the nature of personal frustration and lack of fruitful achievement.

For the amputee, work training affords an additional opportunity for determining how well he conditions himself to the demands of the job both as to general fatigability as well as adaptation of the amputation stump to the job requirements.

W.A., Aviation Machinists Mate Second Class, who lost his right leg below the knee, will find a place with his uncle who operates a large mechanical dental office. Work training has been provided for him in the Navy dental clinic.

H.A., Gunner's Mate Second Class, with an amputation of the left leg above the knee, wants to become a ballistics expert and is being given work training in one of the county police offices.

J.B., Sergeant who suffered a gunshot wound of his left hand, is employed at the State Game Farm, Yountville, California, breeding pheasants and partridges.

G.C., Seaman First Class with an amputation of the left arm and with the loss of his left eye is working as a glass blower at the Radiation Laboratory of the University of California.

J.G., Private First Class, with an amputation above the knee, is a refrigerator mechanic for a large bottling company in Vallejo.

Others are employed in aircraft assembly work as electricians and machinists, as bookkeepers, draftsmen, printers, telephone service men, auto repairmen, wholesale meat handlers, radiomen and so forth. The many industrial and commercial enterprises in the vicinity of the hospital are glad to employ these boys. The employers are assured of loyal, competent and eager service. The trainees are provided with opportunities that galvanize latent powers into action.

There are some for whom large pay, steady employment or professional careers are no great incentive. B.S. Coxswain wants to be a skating rink manager, but he is taking typing at Evening School in order to be able to meet some of the business problems of that type of job.

G.P., Private First Class, was formerly in the show business. Vocational training held no appeal for him; for even with his leg amputation he still feels that he can go back to the kind of life which has always meant color, excitement and deep emotional interest for him.

Thus it can be seen that mass production methods cannot be applied to the solution of the individual problems of the amputee. Certain principles, however, must be observed. In the first place, physical restoration must be complete. By this we mean that surgical and medical care must have been completed and that the loss of a member must be replaced by the best type of prosthesis. It means also the type of convalescent training and conditioning physically and mentally which will restore the patient's general physical constitution to the best possible state and provide him with a new outlook on life. It means also those technical measures in the field of occupational therapy which will help him rebuild impaired structures and restore their

function. The second phase is that of vocational guidance and training, and here common sense must be the basis for the dispensation of advice and counsel.

It is necessary to avail ourselves of the assistance of all those agencies and groups that are participating in the national program for the final adjustment of the individual to civilian life. To this end, a full time representative of the United States Employment Service is in the hospital for the purpose of completing the details necessary for the final referral of the amputee to a specific job in his home community. Registration with this service assures the amputee of direct contact with its Veterans' Representative in his home city. The job begun in a work training project at the hospital or a similar one can thus be continued after discharge.

A full time representative of the Veterans Administration is also on the premises. All veterans service benefits are explained to the amputee before he is discharged and the necessary forms completed to establish his right to pension and other benefits. Through this same representative, vocational training begun at the hospital may be continued under the auspices of the Veterans Administration without any time lag because of discharge.

But for the value of the program let us look at the records of a cross section of discharged amputees. How have these amputees fared in returning to civilian life?

CS, Private First Class who lost his right arm at the shoulder at Bougainville has had continuous employment with an automatic music company. In addition to this satisfactory work adjustment his adjustment to community activities is 100 per cent."

Liaison officer between workmen and engineers is the position enjoyed by HS, Private First Class who lost his right arm at the shoulder at Cape Gloucester. Harry's preference is for electrical engineering and he plans with the assistance of the Veterans Administration to take a refresher course in his chosen field in a year and eventually go into business for himself. He is a prospective father and takes great pride in his home which he is remodeling and redecorating himself.

Since his discharge MB Fireman First Class who suffered an amputation below the right knee at Guadalcanal has been continuously employed as a machinist in a welding shop. He enjoys a full social life and uses his artificial leg so skilfully that many persons have no idea he has lost a natural leg."

In the words of one patient, H S, Pharmacist's Mate Second Class, "We never thought much about rehabilitation until our present pre-

dicament      It can mean everything or nothing      Everything to the man who is farsighted enough to realize that soon he will be out in civilian life competing with men like himself who have recently been discharged      "

Other wars with their quota of disabled veterans have left many with the disillusionment of broken promises. It is the aim of the Rehabilitation program at Mare Island to fulfill these promises not after demobilization but before discharge, thus realizing the ideal that "the object of all help is to make help superfluous."

## REHABILITATION IN HEAD INJURIES

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RECENT publications provide a comprehensive picture of the rehabilitation of head injury patients, particularly during their period of convalescence. It is the purpose of this paper to portray the plan advocated in a Naval Base Hospital stationed in the Southwest Pacific during the early months of the present war and to present the general plan of handling patients with head injuries upon their admission to a Naval Hospital in this country. The initial treatment of the patient with a head injury may be the most important in his entire program. Therefore, the various stages in the care of these patients will be reviewed.

### INITIAL TREATMENT OF HEAD INJURIES

**Concussion Injuries**—That group of patients frequently referred to as blast concussion cases, in which there is no external evidence of trauma with the possible exception of a ruptured tympanic membrane, will frequently need adequate barbiturate sedation, much reassurance and sometimes restraint. Early evacuation of these individuals from the active combat zone is desirable, though many can be returned to duty.

**Severe Intracranial Trauma without Compounding**—The cases of severe intracranial trauma in which there is not a compound wound, as might be produced by being struck with a blunt object or by being blown against a tree or building, require careful observation for progression of signs which may indicate massive intracranial hemorrhage (intra- or extracerebral). The state of consciousness, pulse rate, pupillary signs, deep and superficial reflexes, motor malfunction and changes in any or all of the above are signs of much value. Brief notes made by the early examiners of such patients are of inestimable value and should accompany each patient as he is evacuated. Supportive treatment may be indicated in some patients of this group, and in those in whom cerebral edema appears to be producing alarming signs hypertonic solutions may be utilized to advantage as may a carefully done spinal puncture with the slow withdrawal of small quantities of spinal fluid. Rarely, a midline suboccipital trepanation over the cisterna



magna with continued cisternal drainage by means of a rubber dam will result in almost phenomenal improvement in the individual with marked respiratory difficulty.

This group of patients, including those with cerebral contusions, lacerations and diffuse petechial hemorrhages, is aided materially by the application of nursing details which are often regarded as trivial. Elevation of the head—the circulation and state of consciousness permitting—is valuable in aiding venous return from the head and in lessening edema and diffuse cell destruction. If the patient is comatose, he should be semiprone to permit the external escape of salivary and nasal secretions so as to lessen the likelihood of aspiration with a resultant pulmonary complication. Changing the position of the patient every few hours if his condition permits also aids in combating pulmonary infection. An adequate fluid intake is essential and can be supplied through a nasal tube if the patient remains in an unconscious state. Lavatives, sedatives, sulfonamide preparations and essential food stuffs can also be administered through the tube.

The barbiturates are most satisfactory for sedation (given orally by nasal tube, or rectally) and aspirin and its compounds, with or without codeine, are used for relief of pain. In general, morphine is not used because of its depressant action on the respiratory centers which may already be overtaxed and the pupillary constriction it produces. However, if the patient is suffering from painful injuries elsewhere, morphine should certainly be given. Dilaudid has been observed to produce a striking diminution in signs indicative of midbrain irritation without causing any deleterious effect on the respiratory centers. Paraldehyde is given to the patient who is excessively irritable or violent—usually by rectum.

**Compound Fractures of Skull**—The initial treatment of the patient with a compound fracture of the skull resolves itself into a few simple procedures. Obviously, shock must be combated, if present, and plasma is invaluable. The head wounds are adequately cared for temporarily by shaving the hair short for about 2 inches around the periphery, excising all devitalized scalp and coating the wound well with sulfanilamide crystals. Practically all of the head injury cases that came under our observation had some sulfonamide preparation in the wound and in none of these individuals was there any evidence to suggest that the presence of the drug was in any way harmful. A dry dressing should be fastened securely in place, as can readily be done with the stockinette type of covering. Vaseline smeared about the periphery

of the wound diminishes the amount of foreign material which can enter after it has been dressed. An early booster dose of tetanus toxoid is advocated. Patients with compound fractures of the skull who are conscious are started immediately on one of the sulfonamide preparations, preferably sulfadiazine in a dose of 2 gm followed every four hours by an additional gram, for several days.

### TRANSPORTATION

Transportation of the patients with head injuries was so satisfactory as to make that problem a minor concern. The first stage back was by litter, and from the first hospital area ambulances were available. Practically all of these patients were brought to the island where our hospital was set up by transport planes. This necessitated a six to seven hour journey by air, but the patients tolerated the trip very well in almost every instance. Occasionally a patient with severe intracranial injury would exhibit restlessness and mild respiratory difficulty if bad weather forced the pilot to fly at higher than optimal altitudes, but with a descent to a lower level the patient would quiet down.

### BASE HOSPITAL MANAGEMENT

The hospital which is to handle head injuries should be fully equipped. At least one neurosurgeon trained in the treatment of acute head injuries should be on the staff, and there should be able assistants. Adequate x-ray facilities are essential. A nursing staff with training for this type of work is highly important. Equipment must be complete including suction, electrosurgical unit and metal clip set for hemostasis.

**Treatment upon Admission**—Upon arrival at the base hospital, head injury patients are taken by ambulances, in the same litters they occupied in the plane, to the neurosurgical ward and there transferred to a surgical bed. Those who are conscious and able to swallow are given nourishing fluids. An appraisal of the local and general condition of each patient is made and stereoscopic roentgenograms are made as soon as the condition of each permits. With these exceptions, unless there is obvious reason for immediate surgery, the patients are disturbed as little as possible for twelve to eighteen hours. Sulfadiazine therapy as outlined earlier is initiated shortly after admission and an effort made to keep each patient receiving sulfadiazine on a charted intake of 3500 cc or more of fluid. Sodium bicarbonate is given in conjunction with the sulfadiazine. A nasal catheter is introduced into

the stomach of patients who are unconscious and fluids, sedatives and other medications and nourishment are given through it. An indwelling catheter is secured in the bladder of the unconscious patient and drained every three or four hours.

**Operative Treatment of Compound Fractures of Skull**—The operative treatment of compound fractures of the skull is simplified as much as possible. The scalp is shaved completely immediately before operation (a wide area about the wound having been shaved at the first dress-



Fig. 220—Patient J. P. X-ray showing occipital defect with metallic foreign body near midline of left frontal lobe. Further debridement necessary in occipital area but frontal lobe metal will be left alone.

ing) washed with soap and water, scrubbed with ether and coated with tincture of mercuriolate. Procaine 1 per cent locally alone or in combination with pentothal sodium intravenously, is the anesthetic of choice. The scalp and skull are debrided as widely as is necessary to remove dirty and devitalized tissue. Eighty per cent of our patients had penetrating wounds of the dura and in these the dura was likewise debrided. Damaged cortex is removed by suction and the electro-surgical loop unless the area involved is considered essential (motor, visual or speech cortex). The removal of this tissue is facilitated by

adequate lighting, irrigation with normal saline ( $105^{\circ}\text{ F}$ ), controlled suction, and the use of electrocoagulation and silver or tantalum clips. Fibrin foam was not available but it should prove a valuable adjunct. Foreign bodies that are accessible are removed unless the procedure will necessitate the destruction of much tissue or of essential areas. Deeply embedded metal fragments are not disturbed (Fig 220).

Sulfanilamide crystals are left in all of the wounds, critical and extracerebral. In some instances when bone wax was not available and oozing from the bone and dura was troublesome, sulfanilamide crystals were packed against the bone or dura with a resultant cessation of the oozing. The dura is closed when possible, however, if the wound which is being debrided is several days old, it is better to cover the dural defect with tantalum foil (or fibrin film if it is available) than it is to slide in adjacent dura and in so doing break down already established barriers to infection. Closure of the debrided scalp wound is facilitated by stripping the aponeurosis from the underlying tissues. Parallel incisions may be required to further loosen the scalp so that the bony defect may be covered. None of the wounds in our group of cases were drained. Closure of the scalp is effected with one layer of interrupted silk sutures. Spinal punctures for drainage were done in some instances to lessen tension on the wound.

There is still much debate on how long following injury a compound fracture of the skull may be operated upon with safety. The average time intervening between injury and operation in our group of patients was 5-6 days. Some of these patients were evacuated from our hospital a few days following operation so that an adequate follow-up was not possible. However, in none of these patients was there evidence of meningitis while they were under our observation. One patient developed a superficial infection in a postoperative hematoma of the scalp wound, but this infection subsided in ten days. Another patient entered our hospital with a large and grossly infected compound fracture of the frontal area and we are informed that he later developed two cerebral abscesses. No penicillin was available at this base hospital.

Only one patient with an extradural hemorrhage was encountered. Five hours following injury a subtemporal craniotomy was done and a large extradural clot removed and the bleeding vessel ligated. A decompression was not carried out because of difficulty encountered with dural oozing. His postoperative course was uneventful. Subdural hematomas were treated by removal of the clot with suction and irri-

gation and a small decompression through which drainage was effected with a Penrose drain for twenty four to forty eight hours. Spinal puncture for drainage of fluid was employed postoperatively if deemed necessary.

**Convalescent Care**—Practically every patient with a compound fracture of the skull had one or more other wounds and his convalescence was altered by the nature of those wounds. In general the patient was kept in bed for at least a week and then gotten up for short periods and encouraged to progress as fast as his general condition permitted. Patients who were not paralyzed were assigned to helping those in the ward with incapacitating wounds and the care the latter received by these untrained ward workers was heartening. At first it seemed that segregation of the head injury patients would be beneficial but it was soon apparent that the patients were more cheerful and interested to a greater degree in their progress when they were in a ward where other types of patients were being treated. It was found helpful to trace other members of a man's unit who might be in the same hospital—such contacts aiding the individual's morale and frequently providing valuable data regarding the manner in which he was wounded. Patients able to be up and about were permitted to visit the movies nightly and in general were entertained by such diversion. A few of these patients and almost without exception they were ones who did not have penetrating wounds of the head were upset by the movies or news shorts in which battle scenes and sounds were reproduced.

Patients who had been sent to the base with a diagnosis of concussion or blast injury were usually handled by the neuropsychiatric department inasmuch as the symptoms complained of were indicative of unrest necessitating mental observation. All of these patients were examined carefully from a neurological standpoint but only rarely was there demonstrable evidence suggesting organic brain damage.

#### MANAGEMENT IN THE GENERAL HOSPITAL

All patients with severe head injuries were evacuated from the base as early as their condition permitted when transportation was available. This seemed a logical procedure since the hospital and ambulance ships were well staffed and able to care for such patients satisfactorily. It was felt that patients could safely be moved within a short time following surgery if their general condition was good and to our knowledge no ill effects were produced by such a procedure. Patients

who had sustained a concussion or who had evidence of cerebral edema and possibly a slight contusion were retained for treatment and some of these were able to return to duty. Three patients in this group had been struck by falling coconuts. Each man had been knocked unconscious, but none had evidence of skull or brain damage.

Head injury patients received in a naval hospital in this country from overseas are in varying stages of healing and convalescence. Some need further investigation. Some need plastic surgery and others require only vocational guidance.

Almost all of the patients who return from a combat area following head injuries complain of headache. Some of these patients are relieved by hospitalization or duty in a cooler climate. Others improve rapidly following or coincidental with a leave.

**Encephalography**—Many of the patients are not benefited by climatic or environmental changes and their condition is difficult to evaluate. It is in this group that encephalography is helpful both as a diagnostic and therapeutic aid. Encephalography is not carried out until a careful neurologic examination has been made, and papilledema is regarded as a definite contraindication to such a procedure. The technique that has been found to be most suitable is the simplest, that employing one spinal puncture needle and using air for the contrast medium. Many complicated set ups have been observed, with different gases injected, but the exchange of 10 cc of air with 10 cc of fluid until the desired amount has been injected has proved quite satisfactory, contrary to the criticism offered that such a method in reality 'massages' the brain. Congenital lesions, post traumatic atrophy, gliosis with retraction of the brain and hematomas may be visualized by this procedure.

The treatment, if any, in these cases is indicated by the findings on encephalography. A few patients who have adhesions between the arachnoid and dura will show, with special studies, collections of air in the subdural space. The exchange of spinal fluid and air initiates the tearing of these adhesions and permits the escape of air into the subdural space. The passage of this subdural air over the cerebral hemispheres by rotation of the patient's head seems to relieve the headache in a small percentage of individuals, theoretically by breaking arachnoid dura adhesions which produce pain by traction. Other patients seem to be relieved of headache following encephalography when no abnormal findings are visualized. Still others are not improved after air studies and must be investigated for systemic lesions and frequently from a psychiatric angle.

**Late Treatment of Open Cranial Wounds and Skull Defects.**—The treatment of open cranial wounds in a late stage, *i.e.* after several weeks, is one for much discussion. For example, a patient who had a large left parietal wound seven weeks preceding admission now has a wedge like defect of his head—scalp, skull, dura and cortex—so that it has the appearance of a melon with a slice removed (Fig 221). An abscess has developed in the wound of the brain, and the abscess has been drained. Now there is an exposed surface of brain, roughly 5 1/2 by 3 0 cm. sunken 3 5 cm. beneath the skull when the patient is



Fig 221.—Patient A. F. W. Photograph showing large area of exposed cortex

kept in a low Fowler's position. It is probably best to follow the bacterial flora on the surface by cultures and to utilize sulfonamide therapy and penicillin locally and by injection, and, when a propitious time arrives, to close the defect with a tantalum plate and slide scalp over this metal insert.

In recent months, conflicting opinions have been published on the use of tantalum in repairing skull defects, particularly those defects in which the tantalum will be in contact with underlying cortex. Fibrin film has not been available to this hospital and in its absence tantalum

has been used for repair of bony defects, even though there is no dura between the cortex and the metal

The reasons for using foreign material for covering a skull defect are multiple, viz improvement in the appearance of the individual's head, prevention of adhesions between the scalp and cortex, obviation of the symptoms of lightheadedness, dizziness and of the brain's "falling out" complained of by patients with large cranial defects, and protection for the cortex from external trauma plus the feeling of assurance such protection affords the individual. Various types of re



Fig 222—Patient A B Preoperative photograph showing marked parietal depression (See also following page)

pair with plastics and metal have been described, and they will not be reviewed here. Suffice it to say that the more complicated procedures are not the ones of choice merely because they require much preparation and multiple stage operations.

Tantalum can be handled easily at the operating table—it can be cut with bandage scissors, molded to the desired shape with pliers and an old rongeur or rounded by tapping with a mallet on a rounded piece of wood, and fixed securely by multiple sutures through the periphery of the metal and the bony defect. Where the junction of





Fig 223



Fig 224

Fig 223 Patient A B Preoperative x ray of skull showing large parietal bone defect and infected fragment of bone (See also preceding page)

Fig 224—Patient A B Postoperative x ray showing tantalum plate on lateral view Tantalum foil used at edges where junction was incomplete



Fig 225—Patient A B Postoperative photograph showing improvement in former defect

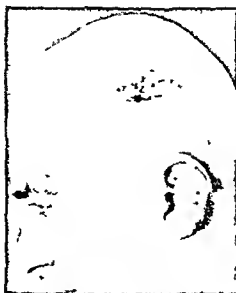


Fig 226—Patient R. D. Preoperative photograph, showing unsightly scar and depression



Fig 227

Fig 227—Patient R. D. Preoperative x-ray revealing bony defect, left parietal



Fig 228

Fig 228—Patient R. D. Encephalogram, revealing dilatation of the left lateral ventricle, anteroposterior view (See also following page)



Fig 229

Fig 229 Patient R. D. Encephalogram showing dilatation of left temporal horn postero anterior view (See also preceding page)



Fig 230

Fig 230 Patient R. D. Postoperative x ray shows tantalum repair lateral view



Fig 231—Patient R. D. Postoperative photograph showing improved scar and lack of depression

the metal and bone has been imperfect—a matter of millimeters—tantalum foil has been laid across the metal plate and bone to cover the defect and keep the scalp from contacting the cortex. Observation of a patient after the latter procedure confirms the feeling that such employment of foil with plate is suitable in a jagged type of bony defect where one wishes to preserve as much of the remaining bone as is possible. A snug dressing over the wound in which a tantalum plate has been placed tends to lessen the accumulation of blood and fluid between the scalp and the metal and obviates aspiration of such fluid (Figs 222-231).

Insufficient studies have been reported on the use of intraspinal and intraventricular penicillin to permit any dogmatic statements as to dosage but it is obvious at this time that much larger quantities can be safely employed than were at first advocated.

**Patients with Convulsive Seizures**—Individuals with convulsive attacks secondary to injuries in service have been few in our experience and then the pathological findings have been diffuse rather than limited to a single cortical scar or meningoencephalic cicatrix. Pneumoencephalography has been used routinely, electroencephalography not having been available. Vocational training has been instituted and phenobarbital or dilantin therapy employed for these patients. In only one of our patients were convulsive seizures associated with a large hemorrhage in the subdural space and when it was evacuated the attacks ceased.

#### EDUCATIONAL, RECREATIONAL AND VOCATIONAL PROGRAMS

Once the patient is over the acute stage and can be up and about or can be moved about in a wheel chair or can be instructed in bed if he is paralyzed, an educational or vocational program is attempted.

Patients in bed are contacted by the department of occupational therapy and some handicraft which appeals to the individual is taught to him. It is heartening to see how some patients who have been discouraged and tired of their treatment will brighten up and display enthusiasm over some leather work they have turned out or over a model plane they have built. The physiotherapy department contributes much in helping those who are paralyzed by working with them and instructing them in self treatment by exercises.

The patients who are able to be up and active are contacted by the educational officer and their capacities and potentialities investigated. Psychological studies may be made. Much is done for these men by

arranging classes for them at high schools, junior colleges and universities in subjects the individuals desire to pursue in order to complete pre-war courses or to fit themselves for some type of work they plan to engage in following their discharge from the service. Intensive courses are not given at first.

Considerable recreation is encouraged and the recreation officer provides many facilities for such. Athletic equipment of many types is available. Concerts by orchestras and bands do much to divert patients from their worries. Dances are held where the men can go and find suitable partners. Many service clubs entertain frequently for groups of patients and provide an evening of fun and diversion. Trips to the races are sometimes available. One of the most valuable breaks in hospital routine has been provided by trips of from one half day to several days, sponsored by the Red Cross workers. The trip may be for sight-seeing, or may include a horse show or a picnic, or may encompass a visit to some ranch home where several patients are house guests for from one to seven days. A few weeks stay at one of the convalescent hospitals has done much to buck up the spirits of lads who have been unable for one reason or another to reach home for a leave.

Patients who have some handicap which prevents their return to duty or discharge from the service are often permitted to obtain jobs on the outside. The openings are numerous for such men and those who have secured work really feel that life does hold a future for them. These men report in to their medical officer once a week for consultation and if physiotherapy is indicated arrange to visit that department at an hour which will not conflict with their work.

Considerable effort is made to drive home to these patients who have had injuries to their intracranial content that they will not tolerate alcoholic beverages as well as those of similar capacity with non-traumatized brains. Usually, no heed is paid to the first suggestion but repeatedly, patients who are subject to convulsive seizures will have attacks following alcohol ingestion, and additional advice relative to not drinking intoxicants is adhered to—at least for a short time.

One of the special types of training that has proved invaluable is that of *speech training* for the patients who have a motor aphasia. The individual patient receives careful instruction beginning with the formation of various sounds and is carried through combinations of sounds to forming words and then sentences. Inasmuch as the aphasic patient usually has a hemiparesis or hemiplegia some other patient

who is a close buddy helps with the nursing care. It has been the practice to have the buddy sit in on the speech training and then spend much time out of the formal class helping the patient learn and relearn his sounds, vocabulary and phrases. The work that these voluntary assistants have done is a tribute to unselfishness in American youth.

The speech teacher can accomplish much by his or her own ingenuity. Our patients have been fortunate in having one who enters for them at home, and insists on their talking and asking for things desired before they are supplied. This type of training has without question been grossly neglected in the handling of individuals with aphasia. Patients who have had a transient aphasia and recovered have stated that when they were aphasic they felt completely helpless and dreaded living if such a state was to be permanent. The enthusiasm shown by our patients with aphasia when they have mastered a new lesson and the hope which is engendered in them by such an accomplishment is in itself inspiring.

#### ENCOURAGEMENT AND REASSURANCE

Throughout the entire care of the head injury patient he must be encouraged and reassured as to his future. The lad with a fresh wound, when conscious, needs a few encouraging words to carry him through the acute stage when he first realizes that his brain has been damaged. Later the patient needs the encouragement of his medical officer while in the trying period of plastic repair and vocational training. Before he returns to civil life he profits greatly by the reassurance his medical officer gives him by helping him to secure a job so that he can realize he has the ability to earn a living. With this realization he will gain confidence in himself. These patients must be trained, as it were to the stage where they have the physical endurance and mental outlook which will enable them to carry on their work against odds when they are discharged to civil life. Such training will do much to lessen the percentage of failures and will decrease the number of men who become chronic patients in our Veterans Administration Facilities.

# PHYSICAL RECONSTRUCTION IN ORTHOPEDIC DISABILITIES

## A Major Rehabilitation Problem in Time of War

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ANORL DIOE once remarked 'All has already been said, but as no one has listened, it is always necessary to start over again.' This statement is not applicable to the physical reconstruction of orthopedic disabilities, for while much has been discussed and written about the subject, all has not been said. The following statement, however, does apply: 'Much has been said, but as few have listened in time of peace it is always necessary to start over again in time of war.' In peace orthopedic disabilities are of minor interest to physicians, who see few such cases in their practice. In war the number of orthopedic disabilities is great and the subject of their reconstruction becomes of major importance to all doctors. Disabled servicemen are now beginning to return to their home communities and to command the interest of every physician and layman. It is most important now that every doctor have an accurate knowledge not only of the causes of these disabilities but also of effective measures for their reconstruction. To present a brief outline of this knowledge is the purpose of the present article.

First, it should be pointed out that the transformation of a physically wrecked individual into a useful, self-supporting citizen is not a chance happening but the result of a careful plan which includes the active cooperation of many members of a reconstruction team. For the physical and mental rehabilitation program the physician should be the captain of a team in which the physical therapist, the occupational therapist, the academic teacher, the director of vocational guidance, and the director of vocational rehabilitation all play very active parts. Later, as the final stage of the medical program is reached the director of vocational rehabilitation assumes greater responsibility. When maximum physical reconstruction has finally been obtained the doctor plays a relatively inactive part, becoming an advisor, while the trained rehabilitation officer is now the full time captain. It is his re-

sponsibility to place the veteran in a job which will enable him to be as nearly self-supporting as his remaining physical disability will permit

The choice of reconstructive orthopedic treatment, particularly in the case of surgical procedures, is to a large extent governed by considerations of vocational rehabilitation. For example, an operation to increase the mobility of a major weight-bearing joint, such as a hip or knee, partially stiffened by shrapnel wounds, is obviously not indicated if the veteran is required to work in a standing position for long periods of time. End-result statistics show that following such an operation the joint may develop pain and weakness when subjected to excessive activity or prolonged weight bearing. In this instance, an operation to ankylose the joint completely would be the procedure of choice.

After full medical care has been carried out, all planning and training for the veteran's rehabilitation will center around his permanent physical disability. Consideration must be given to his educational status, his adaptability, his intelligence quotient, and his interest. The type of work which this soldier can best carry out with his individual mental status and physical handicap will constitute the key to his final rehabilitation. After all variables have been carefully weighed, the most promising vocational rehabilitation program for the individual is selected.

The orthopedic reconstruction problems of war differ from those of peace only in extent, severity and number. The wounds are more often lacerated and gaping, with extensive loss of muscle and other soft tissues. By far the largest group are shrapnel or gunshot injuries, resulting from booby traps, mines, bombs or rifle fire. The fractures are more frequently multiple, comminuted and compound, 60 per cent of the combat injuries in soldiers now returning from the fronts are compound fractures. Many of the comminuted gunshot fractures show either a loss of extensive sections of bone or multiple small fragments, which present a serious problem in realignment. Due to the frequent military necessity of evacuating the wounded from one medical installation to another, it may at times be days or even weeks before final attention can be given to the proper reduction and immobilization of a fracture. Since the repair of a fracture normally commences immediately following the accident, this delay tends to cause a higher percentage of patients with malunion, delayed union or nonunion than would be found in a similar group of fractures in civil practice. Before



surgery can be performed for the malunion or nonunion, a large defective space in the soft tissues may have to be repaired. This type of wound requires close cooperation between the plastic surgeon and the orthopedic surgeon in planning the most effective reconstructive procedures. Frequently, it may be months before the major orthopedic reconstruction can be undertaken.

The function of an extremity is dependent upon muscle power. Injuries of peripheral nerve trunks may cause complete or partial loss of muscle power and now are associated with approximately 15 per cent of extremity injuries in combat casualties. The repair of nerve injuries by the neurological surgeon is of primary importance in all reconstructive procedures and may be indicated in advance of the orthopedic operation. Frequently, however, it is possible for both plastic and orthopedic or both neurologic and orthopedic procedures to be performed concomitantly.

*Orthopedic injuries of the extremities fall into three groups: (1) those with loss of the distal portion of the extremity, that is, amputation, (2) those with a loss of or break in the continuity of bone without significant soft tissue injury, and (3) those with severe soft tissue damage with or without bone injury.*

#### AMPUTATIONS

Amputation of the lower extremity is approximately three times as common as that of the upper extremity and is many times more important as a reconstructive problem. The three most important factors in the physical rehabilitation of the lower extremity amputee are (1) *the stump*, (2) *the limb fitting*, and (3) *the gait*, for these the surgeon, the limb fitter and the physical therapist, respectively, are primarily responsible.

The ideal stump has a freely movable scar, good circulation and no painful points on weight bearing, and is the result of both good surgical judgment and surgical skill. The clean severance of a nerve trunk which is afterwards allowed to retract into the soft tissues, is followed least often by a painful neuroma. The proper level for the amputation is most important. Experience has taught that long stumps of the lower leg, short stumps of the thigh and stumps at the wrist and elbow are most difficult to care for properly and fit with a prosthesis, they should be avoided whenever possible.

In the fitting of the lower extremity prosthesis, it is paramount that the weight be made to fall on a nontender portion of the stump or

extremity or on the tuberosity of the ischium. It must be realized that, in the experience of most surgeons and limb fitters, a wholly end-bearing stump will seldom remain a painless stump. The choice of prosthesis depends not only on the type and condition of the stump but also on an evaluation of the patient's ability to wear a prosthesis. Accurate fitting of the bucket on the stump and correct alignment of the limb on walking are the most important problems of the limb fitter and are definitely problems peculiar to each amputee.

Teaching the amputee correct gait and good walking habits is the third essential step in the rehabilitation process. If use of the limb is started incorrectly, the skin of the stump may break down and the limb may prove uncomfortable; the amputee may become dissatisfied, and his morale, which often is poor to begin with, may become critically low.

If sufficient care and attention are given to these three steps, the amputee should maintain a good morale and rapidly adjust himself to his handicap. If one or more of the three steps has not been correctly completed, the amputee may become a constant source of worry to the surgeon, the limb fitter and the physical therapist, and his rehabilitation may be extremely difficult.

The problems in amputations of the upper extremity are few. The preparation of the stump is the same. The prosthesis is not difficult to fit, and its use is easily mastered. It is always surprising to find how quickly an arm amputee becomes expert in the use of his appliance. A double hook (Dorrance type), which can be separated and approximated with force similar to the grip between the thumb and the first finger, is always more effective and useful in ordinary work than an artificial hand.

#### INJURIES CHARACTERIZED BY A LOSS OF OR BREAK IN THE CONTINUITY OF BONE WITHOUT SIGNIFICANT SOFT TISSUE INJURY

This group constitutes the largest number of orthopedic injuries. It includes all fractures, both simple and compound.

In the treatment of orthopedic conditions affecting the lower extremity, the first and foremost object is *stability*. In planning treatment, the surgeon must first answer the question: "How best can stability be obtained in the shortest possible time?"

**Simple and Compound Fractures.**—*Simple fractures*, if early adequate reduction and immobilization without distraction are effected, will heal promptly in 95 per cent of the cases. Furthermore, if correct

alignment is maintained during the healing process, no problem in rehabilitation should be offered. Unfortunately, in time of war, such variable factors as equipment, training of the medical officer, working conditions and the like may make the accomplishment of satisfactory treatment impossible. Every medical officer treating bone injury is not a fracture specialist and is frequently working under very difficult conditions with inadequate equipment. Results obtained under such circumstances are variable, sometimes excellent, at other times poor. The poor results may consist of malunion of the bone, stiffening of the joints and extreme atrophy of muscle and bone. When these complications occur months of surgical treatment, including osteotomies, bone grafts, tendoplasties and so forth may be necessary before maximum benefit has been received from medical care.

If the fracture is *compound*, as are 75 per cent or more of the fractures present among battle casualties, the healing process may be retarded. Fortunately, in this war, the infected fracture with months of purulent drainage is not so common as in the last war. Compound fractures are now being successfully converted to simple fractures in the combat zones in from four to nine days after injury by closure of the open wounds under penicillin "coverage." A true osteomyelitis contiguous to a fracture site is now extremely rare. When it does occur, it is usually due to (1) delay in debridement occasioned by uncontrollable circumstances, (2) incomplete debridement in the initial definitive surgical treatment, or (3) incomplete removal of dirty and unattached fragments of bone. This favorable situation is a tribute of course, to the effectiveness of early use of the chemotherapeutic agents, penicillin and the sulfonamides. Even infected fractures will often heal if immobilized satisfactorily. If the infection is of low virulence it may stimulate rather than retard bone formation.

The *circulatory and neural complications* of these fractures sometimes constitute the most serious phases of the injuries. Fortunately, a true Volkmann's ischemic paralysis accompanying fracture of the upper extremity is a rare occurrence. The same condition is observed occasionally in the lower extremity. Obstruction of the circulation externally by improperly applied plaster casts and splints is more common than internal obstruction from factors such as arteriospasm and blood clot. In the treatment of these conditions, surgery is seldom indicated. Therapy is directed toward establishing a collateral circulation and correcting or preventing contractures by the use of splints and the physiotherapeutic measures of heat, massage and exercises.

Early repair of the severed peripheral nerve is always indicated and should be done by the neurosurgeon oftentimes before indicated bone surgery. The results of late repair are definitely unsatisfactory as compared with those of primary suture.

In the early period of this war, the Orr-Trueta or *closed plaster method* of treating compound fractures was used extensively. This method involved the use of prolonged, uninterrupted and continuous immobilization of the part through efficient plaster fixation after a complete removal of all dead and infected tissue. However, due to the decrease of infected fractures and wounds, and the large number of dead legs which followed this treatment, it is being supplanted by traction suspension with early motion of all parts of the injured extremity. Plaster immobilization for simple and compound fractures of the long bones of the lower extremity is now being recommended only during the period when the patient is being transported.

When the fracture has healed in good alignment, the next problem is the restoration of joint motion and muscle power by a convalescent training program which includes *physical and occupational therapy*. In the early stages, the patient is encouraged to contract his muscles actively and move his joints to prevent stiffening and loss of muscle power especially in the case of extensively comminuted or comminuted compound fractures treated in traction suspension. The importance of activity at the earliest possible moment is being constantly stressed. Prolonged rest with absolute immobilization is the key to treating the slowly healing fracture, but this inactivity should not continue longer than is necessary for bone union to take place. Walking casts are being used for leg, ankle and foot fractures, while walking calipers are used for fractures of the femur.

**Nonunion**—If fracture healing has not occurred after immobilization for the usual period of time a revised plan of treatment must be considered. This plan may not involve surgery, for the lower extremity the wearing of a walking cast or caliper brace may suffice. Weight bearing on an extremity with a slowly uniting fracture may stimulate bone formation and be followed by solid union. If however, non-operative treatment is not indicated or is ineffectual three *surgical procedures* are to be considered for the nonunion without extensive loss of bone, these are, (1) multiple drilling across the fracture line to open new channels for circulation and subsequent ossification (2) exposure of the fracture site, removal of scar tissue and sclerotic bone excision of the bone ends to a point where there is good circulation

and fixation of the fracture fragments with a metal plate and screws, and (3) grafting of new bone across the fracture site. It is not within the scope of this discussion to describe these procedures in detail, any of the three, however, may be followed by solid union of the fracture. Experience has shown that the onlay or the inlay bone graft should be of ample width and length and that it should be securely fixed to the underlying bone by metal, preferably a nonelectrolytic alloy such as vitallium or tantalum. In the hands of most surgeons, the metal screw technic of fixing the bone graft has proved to be superior to methods of fixation with absorbable sutures of catgut or kangaroo tendon or nonabsorbable sutures of wire or heavy braided silk. Following any of the three operative procedures it is necessary again to immobilize the part efficiently until there is roentgenographic evidence of new bone formation and clinical evidence of rigid union.

**Large Bone Defects**—The long bone fracture with a large bone defect, seen most frequently in the tibia, presents the most serious problem in fracture surgery. A popular procedure is the use of a portion of the fibula because of its strength and stability, at times as much as three fourths of its length may be required. An alternative method is to take a long graft from the remaining portion of the fractured bone or from the normal tibia. In placing the graft, extreme care must be taken to remove all avascular tissue and to secure firm fixation without motion of the fragments on either side of the defect. This can best be accomplished by dovetailing the ends of the graft into prepared ends of the fragments and by utilizing vitallium screws. The results of this type of grafting operation are good if meticulous attention is paid to the details of operative technic, but are not so good as those of grafting operations in which the fragment ends can be approximated.

#### INJURIES CHARACTERIZED BY SEVERE SOFT TISSUE DAMAGE WITH OR WITHOUT BONE INJURY

The repair of soft tissue defects may have to be effected before consideration can be given to a surgical procedure on bone. This is especially true if the local circulation is impaired by a scar tightly adherent to underlying bone. In this instance a complete resection of the scar and the application of a full thickness skin graft to the denuded area may be the procedure of choice. To help to fill in a gaping defect, the skin graft may contain subcutaneous tissue and be lined on its undersurface by fat or muscle. A bone graft should never be at

tempted when scarred skin is adherent to bone at the proposed site of operation. If such a wound breaks down, it is impossible to prevent infection from developing, and in most instances, such infection will prevent the graft from uniting to the bone fragments and so completely annul the effect of the operation. In some instances the plastic repair may require many operations over a period of months. During this period, all orthopedic operations must be held in abeyance. The plastic surgeon may wish to repair severed tendons while correcting the skin defects. This is often the case when the injury involves the wrist or hand. The number of severely crippled and poorly functioning hands is large. Each case is definitely an individual problem. Usually the skin defect and joint contractures form the most serious source of disability and demand months of work by the plastic surgeon before the end of the surgical phase is reached. This must be followed by a long period of active physical and occupational therapy, which may or may not result finally in a usefully functioning extremity.

The repair of large soft tissue defects and scar tissue contractures about the joints constitutes the most important work of the plastic surgeon in orthopedic reconstruction. After the plastic surgeon has successfully closed a defect or released a contracture, the restoration of joint motion and muscle power can begin, now the rehabilitation process becomes primarily orthopedic. During all of these procedures frequent consultation between the plastic surgeon and the orthopedic surgeon has been essential.

#### INJURIES OF THE SPINAL COLUMN AND THORAX

Injuries of the spinal column and thorax are of much less frequent occurrence than those of the extremities. The orthopedist may be associated with the thoracic surgeon if the injury involves the chest, or with the neurosurgeon if the spinal cord or peripheral nerve roots are affected. If the healing of a fracture of the spine is followed by pain and weakness, a stabilization operation including several vertebrae may be indicated. This, however, should never be done until (1) it has been ascertained that the pain can be relieved with proper rest and support and recurs again on activity, and (2) the surgeon is convinced that the patient is a mentally stable individual. Partial or complete paraplegia following trauma becomes a problem for nonoperative physical reconstruction when surgery is not indicated. The number of cases is unfortunately large. The application of braces and instruction

in their use form a most important part of the care of this type of patient. Active muscle reeducation with heat and massage to improve the circulation and tone should always be employed in association with instruction in walking. These physical therapy measures are most important adjuvants in the rehabilitation of all orthopedic disabilities and normally are used following all surgical procedures on the extremities. A well rounded convalescent training program is always a most valuable adjunct in enabling the injured veteran to attain the ultimate goal of maximum improvement of his orthopedic disability.

### CONCLUSION

The importance of cooperation between the surgeon and the other members of the rehabilitation team should again be emphasized. All members of the team should be in absolute agreement concerning the plan of rehabilitation, including its medical aspects. Although the surgeon may enthusiastically advocate a certain operative procedure permission for the operation should not be granted if its result is in doubt or if it will not produce a soldier better qualified for vocational rehabilitation. Teamwork is the key to all rehabilitation and the surgeon who works for physical reconstruction is an indispensable member of the team which is planning and effecting the return of the disabled serviceman to a normal place in society.

## PHYSICAL MEDICINE IN A REHABILITATION PROGRAM

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ALL branches of the military service, Veterans Administration and civilian medical departments are stressing the importance of rehabilitation. Large, in his report on the British system of rehabilitation stated that "Rehabilitation may be defined as restoration to a state of robust health after injury or illness. It thus connotes the restoration of free movement to stiffened joints, of vigour to tired minds, of courage and confidence to quailing spirits—in short—the physical, mental and ethical toning-up of the whole individual being. Obviously necessary physically for most persons before resuming work after even a week in bed, it is less obviously—but perhaps urgently necessary psychologically." Jostes<sup>3</sup> defined rehabilitation as "nothing more or less than the conscientious planning and execution of those procedures which the practice of medicine offers as a restorative measure to a person suffering from any given disability, which inhibits the individual from taking part in activities of a normal man, be they military or civilian." Bilik<sup>4</sup> stated that rehabilitation is the use of physical therapy, recreational therapy and physical training to promote and hasten recovery from illness or injury.

Rehabilitation has as its goal the restoration of earning power of the disabled person. It implies more than good medical treatment. The use of blood plasma, penicillin and perfected technics of evacuating wounded from battlefields may save the life of the wounded soldier. However, it is not enough to transport the wounded to the hospital quickly and to provide medical and surgical treatment promptly in an attempt to save life and restore health, there is a larger obligation to ease mental suffering and restore the patient to a full, useful life. Rehabilitation must be a phase of therapeutics dispensed by a well trained physician who has had training in physical education and physical medicine and has some concept of correct psychiatric treatment.

The preservation of the health of our servicemen and our civilian population is the responsibility of the Medical Departments of the

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Army, Navy and Veterans Administration and of the civilian medical groups. This war with its large number of casualties and the present acute shortage of manpower has made the nation conscious of the necessity for making use of all the facilities at hand to restore the handicapped person to a richer, fuller life. Because of these conditions a great number of rehabilitation activities are being started and many governmental agencies are taking an active part in this program. The Army, Navy and Veterans Administration already have well formulated programs under way. The Office of Vocational Rehabilitation of the Federal Security Agency is directing a nationwide program through state agencies for the rehabilitation of disabled civilians. The United States Employment Service is placing handicapped persons in industrial positions which are within their capacity. There are many private groups or agencies that are concerned in the rehabilitation problem. Among these may be mentioned physicians, nurses, occupational therapists, physical therapists and many organizations that specialize in the training of the deaf, blind, physically handicapped and psychiatric patients.

The value of adequately planned convalescence has been demonstrated by the British. One of the first rehabilitation centers to be established was in the Royal Air Force. This center was organized within a few months after the outbreak of the present war. Under the leadership of Watson Jones, rehabilitation centers were developed in ten Royal Air Force orthopedic centers and five special rehabilitation centers were also instituted. Of the thousands of injured men admitted more than 95 per cent went back to duty.<sup>2</sup> More than 25,000,000 man hours have been conserved in fifteen months by the rehabilitation program of our American Army Air Force.<sup>3</sup>

The Army, Navy, Veterans Administration and many of the leading universities have taken up the task of making the rehabilitation program a success. The Army Medical Department has enlisted or commissioned a large number of physical education instructors to carry on the rehabilitation program. A Women's Army Corps recruiting campaign to supply reconditioning personnel has been very successful. The rehabilitation program of the Navy Department as organized by the Bureau of Medicine and Surgery has been in progress since April 1944. The program aims to secure maximal adjustment of the individual patient either for further military service or for return to civilian life. There are being developed facilities in occupational therapy, physical therapy, recreation, welfare service and education,

and in addition, for those to be invalided from service, counseling, pre-vocational guidance and information regarding employment.<sup>2</sup> The University of Pennsylvania is to form a graduate division of physical medicine; Harvard has been granted \$50,000 by the Baruch Committee for the establishment of fellowships in physical medicine; the University of Minnesota Medical School has received a grant of \$40,000 from the same committee "to strengthen its program of teaching and to provide fellowships for a period of three years for men trained in medicine or related basic sciences, to specialize in physical medicine."

The Vocational Rehabilitation Amendments of 1943, which were approved by the President on July 6, 1943, were formulated to provide a wartime, as well as a peacetime, program of rehabilitation for disabled persons. Sherclay<sup>3</sup> has set down a complete plan for the rehabilitation of the disabled person, which includes the following services:

1. *Location of persons in need of rehabilitation.* It is important to locate such cases as early as possible in order to minimize the disorganizing effects resulting from mental and emotional conflicts. Having some assurance that a life of dependency may not be theirs, such individuals can look to the future with hope. The cooperation of all private and public health, welfare and other agencies and of individuals is necessary in locating disabled persons and in carrying out the steps involved in the successful completion of their rehabilitation.

2. *Physical and vocational diagnosis.* As a basis for determining the individual's total rehabilitation needs, a medical diagnosis is required to establish the general health and medical history of the individual, including or including functional conditions. The medical diagnosis includes the type and extent of medical or surgical conditions, taken into consideration, together with the patient's experiences, interests, and aptitudes.

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been distorted by the effects of their wounds or other causes and those with mental and neurological disturbances require psychiatric care in addition to other services.

6 *Vocational training* Those disabled persons whose impairments have incapacitated them for normal occupation or who have never had vocational experience or whose skills have become obsolete due to changing industrial needs resulting from technical developments require vocational training

7 *Financial assistance* Because of the fact that disablement comes more frequently to persons in the lower income groups, many handicapped persons will be in need of financial assistance to support themselves while they are undergoing training

8 *Placement in employment*

9 *Follow up on performance in employment* Follow up is needed to determine whether the handicapped worker was properly placed. Adjustments may be found necessary, medical follow up may be needed, a prosthetic appliance may require adjustment the individual may need supplementary training or he may need some special assistance in adjusting himself to working with others

Physical therapy or physical medicine may be defined as that science which deals with the management of disease by means of physical agents such as light, heat, cold, water, electricity and mechanical agents

There is nothing particularly new or different in the modern concept of rehabilitation. The medical profession has been aware of the importance of care during convalescence for many years. In fact Hippocrates and Galen referred to regulated exercises for the patient recuperating from diseases or injury. The Greek gymnasts taught massage and gymnastics and used these procedures in treatment for fractures, dislocations and wounds. Although physical rehabilitation is one of the oldest branches of medical practice, it has been little understood. The battle injured primitive man who bathed his injured part in a pool of water was practicing hydrotherapy and the primitive mother who rubbed the infant's bruised muscles was practicing massage. Galen and Dioscorides employed the torpedo fish to produce electric shocks in their patients—the beginning of electrotherapy<sup>2</sup>

Physical medicine in the form of hydrotherapy, mechanotherapy, electrotherapy, heliotherapy and occupational therapy has come to play an important part in the rehabilitation program. The value of physical agents and the extent of their use in rehabilitation and reconstruction work have been little understood by the medical profession.

It has been found that in ordinary civilian practice from 5 to 10 per cent of all patients require some form of physical treatment. In one large clinic last year, 9.5 per cent of all patients admitted were referred to the section on physical medicine.<sup>10</sup>

#### DISABILITIES AMENABLE TO PHYSICAL MEDICINE

Wartime physical disabilities which are amenable to physical medicine may be classified into three major groups:

1 *Trauma of soft tissues* Physical therapeutic procedures have proved to be of value in the treatment of such injuries. This trauma often results in torn or thrombosed blood vessels, lacerated tissue infiltrated by hemorrhage, inflammatory exudate with its cellular constituents and the transudate of edema from circulatory and lymphatic obstruction. When the pathologic changes are understood, physical therapy can be instituted in a logical manner. Physical therapeutic procedures have two main purposes to fulfill, to prevent further extension of the pathologic process initiated by the original trauma and to aid in the return of the traumatized tissue to its normal state and function as soon as possible.<sup>12</sup> Included in this classification are contusions, lacerations, strains, sprains and peripheral nerve injuries.

2 *Trauma of the skeletal system*

3 *Postoperative convalescence* In this grouping may be placed the amputation and other orthopedic cases in which the patients have lost the power of normal locomotion.

#### THERAPEUTIC AGENTS OF PHYSICAL MEDICINE

**Cold**—Cold therapy may be defined as the application of cold locally or systemically for therapeutic purposes. Immersion of a part in cold water diminishes the rate of circulation and causes a reduction of temperature in the deep tissues. Bazett<sup>3</sup> found that after immersion of the forearm for one hour in water 50–36° F., there was a temperature of 56.3° F. at a depth of 4.8 mm. and the deep temperature was still falling. Local applications of cold should be used in conditions in which local vasoconstriction is desired. In cases of contusions, strains and dislocations, it is important to use cold applications locally for the first twenty-four hours to lessen extravasation of blood and lymph into the tissues. Cold applications used locally also relieve pain and congestion. Ice packs, cold sheet packs and refrigeration units may be employed as sources of cold. Solid carbon dioxide has been used by

Pusey of Chicago for therapeutic refrigeration. Cold immersions of gradual decreasing temperatures have been used to desensitize patients who have a physical allergy to cold.

**Heat**—Following the initial period of twenty-four hours during which it is customary to apply cold to the injured part, it is essential that heat be applied to improve the blood supply and to promote absorption and healing. These measures, to be effective, must be started early because organization of the exudate begins early. Three forms of heat are commonly used therapeutically—the hot water bottle as a conductive form, the heat lamp as a convective type and short wave diathermy as a form of conservative heat. Heat may be applied in several ways, such as whirlpool baths, radiant heat, hot compresses and short wave diathermy.

The whirlpool bath is a very satisfactory method of applying heat to sprains, strains and fractures.<sup>13</sup> This bath consists of a metal tank in which the water, the temperature of which is regulated, is being continuously agitated by an electrically driven motor or a pipe is adjusted to the intake valve so that air is pulled into the water circuit before it enters the tank and thus air bubbles are added to the whirling warm water. This whirling, aerated bath promotes muscular relaxation, soothes the cutaneous nerves and produces gentle massage. The temperature of the water should range from 105° to 110° F and the part should be immersed for at least thirty minutes.

A number of different types of baths have been used to apply heat to an injured part. Among these may be mentioned contrast baths with the temperature of the water ranging from 65° to 110° F in two separate containers, sitz baths, hand and arm baths, foot baths and half baths.

Radiant heat may be obtained from the luminous or incandescent lamp or from the infra red generator. Coulter<sup>14</sup> has shown that with radiant heat from an incandescent lamp, the subdermal temperature at a depth of 0.5 cm. rose to 47.7° C. Carbon filament bulbs have been used in the smaller lamps but more penetration may be secured from lamps using the tungsten filament bulbs of 200 to 1,500 watt output. The spectrum emitted from a 500 watt tungsten lamp lies between 300 and 4,500 millimicrons with 30 per cent lying in the range most beneficial for local capillary circulation.

Short wave medical diathermy is another very useful method of producing local heat. It has been contended that this type of heat has a selective affinity for different tissues, that is, that one tissue may be

heated more than another. However, Mortimer<sup>12</sup> has shown by repeated experiments that different organs were heated at approximately the same rate. His experiments proved that the blood serves as a very efficient distributing mechanism, for in dead dogs different organs became heated at different rates.

Conventional diathermy has also been used as a source of local and deep heat. This form of diathermy applied locally produces an increased temperature of the tissues and vasodilatation. The cutaneous surface is heated to the highest degree and the temperature of the tissues decreases in proportion to their depth. Binger has found that conventional diathermy does not necessarily travel directly through tissues but takes the course of least resistance.

Short wave diathermy provides an excellent means of producing deep heat for sprains, strains, dislocations, fractures, bursitis and pelvic inflammatory diseases.

**Massage**—Massage may assist in restoring function to an injured part. It reduces the time of immobilization to a minimum. It has both mechanical and reflex effects and by its use it is possible to promote lymphatic drainage and venous flow, stretch contractures, loosen scar tissue, produce relaxation or stimulation, relieve muscular spasm and improve muscular tone. Massage is beneficial in cases of fibrositis, contractures, weak and spastic feet, rheumatoid arthritis, sprains, strains and certain other medical conditions.

In fractures and sprains, deep effleurage and gentle kneading above and below the involved joint or bone are of great assistance in maintaining the circulation of the part. All massage should be preceded by application of heat, and massage, in turn, is a preparation for active or assistive exercises.

**Exercise**—Under this heading we stress corrective or therapeutic exercises that are designed to restore normal function to diseased or injured tissues. Corrective exercises play an important part in the rehabilitation of persons injured in war or in industry.

Exercises are classified under four different headings: (1) passive, (2) active assistive, (3) active and (4) active resistive. In passive exercises the patient does not offer any assistance or resistance. This requires the full cooperation of the patient. In performing such exercises the operator is endeavoring to prevent contractures, adhesions and muscular atrophy. Joints above and below the site of an injury should be put through their full range of motion as soon as possible after an injury. The degree of force should be specified by the attending

physician and should be increased daily until active exercises can be performed. Forceful exercises of a passive nature may be used as manipulative procedures to break down adhesions or such conditions as fibrous ankylosis of joints.

Active exercises imply motion without any external assistance. Active motion is a natural and physiologic function of the muscles and joints and is thus the best stimulus to their proper use and nutrition.

Active resistive exercises are classified as concentric or eccentric. In the concentric the patient makes the motion against the resistance of the operator. Eccentric movements are useful in early stages of recovery from peripheral nerve paralysis as a muscle may be able to offer slight resistance to motion before it can produce motion itself. Many ingenious mechanical appliances have been devised to assist in restoring and improving the functions of the diseased or injured tissues. Stationary bicycles, nautical wheels, ropes and pulleys, skipping ropes, weights, rowing machines and many other devices can be utilized to promote active exercise.

**Occupational Therapy**—This form of therapy plays an important role in the restoration of normal function and the psychologic readjustment of the patient. There is no better way of restoring muscular function of patients who have suffered contractures from burns or fractures, peripheral nerve injuries or plastic operations than by the use of constructive activities. As Girdlestone<sup>7</sup> has stated, in the course of a few days or weeks the shock, toxemia and asthenia following a serious wound or accident pass. Something must be found quickly which will attract the patient, prove well within his powers and throw little or no strain on the damaged part. Compere<sup>8</sup> stated, "With the hands at work the mind is no longer restless." Occupational therapy should be employed in an effort to provide a form of active exercise as well as the creation of some object in which the patient can feel pride.

**Heliotherapy**—Heliotherapy may be defined as treatment by means of solar radiation. Artificial heliotherapy is treatment with lamps with a spectral output which approaches that of sunlight. Ultraviolet radiation spans a range from 136 to 390 millimicrons. The antirachitic band lies in the spectrum between 290 and 313 millimicrons and is able to convert more than 60 per cent of ergosterol into vitamin D. Rays below 290 millimicrons are chiefly the bactericidal and tissue destroying rays. Various sources of ultraviolet radiation are available, includ-

ing the sun, carbon arc lamps, quartz mercury vapor arc, high frequency mercury induction lamp and the cold quartz lamp

Ultraviolet radiation has been used as an adjunct in the management of fractures, superficial infections, osteomyelitis, general debility, calcium and phosphorus deficiency and convalescence<sup>15</sup>

The convalescent centers in Florida, California and Atlantic City which have been taken over by the armed forces have made full use of outdoor sunlight as a valuable therapeutic agent in the rehabilitation program

#### SUMMARY

The rehabilitation of our injured servicemen and civilian population is a growing problem and must be adequately dealt with by responsible organizations. Rehabilitation must restore the patient to a full and independent life. Physical medicine is a growing science and must continue to expand in order to fulfill its share in the rehabilitation program

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## THE UNDESIRABLE EFFECTS OF BED REST

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At this time it is not intended to discuss the psychological effects of bed rest, although these are known to be disastrous in rare cases undesirable in nearly all patients confined to bed for more than a few days, and the occasional cause of chronic invalidism with repeated hospitalization or bed rest for minor symptoms and negligible physical findings. This latter syndrome, rare in private patients, is by no means uncommon in clinic and industrial experience, and among war veterans. But these effects of complete bed rest on the psyche are of such importance that the procedure would have to be evaluated as to possible hazard to the patient even if there were no ill effects on the tissues. The longer the period of bed rest the more difficult and prolonged is the period of rehabilitation of the psyche.

On other occasions this writer and many others have called attention to the hazards of *phlebothrombosis in the veins of the lower extremity and pelvis*, and of *pulmonary embolism*, as a result of bed rest.<sup>1-3</sup> The hazard is greatest in patients well enough to be propped up in bed, so they can read and work at games, often with the legs partly flexed over a pillow or a bend in the mattress. It is far greater in obese patients than in thin ones, in the elderly than in the young, and in lethargic or heavily sedated patients as contrasted with restless ones. While there is a great variation in incidence and recognition of this complication of complete bed rest, in different parts of the country and in different hospitals in the same area, it has become one of the most frequent causes of death following operation, or during medical care of chronic and acute diseases of the senescent and senile.

As the mortality from shock and infection is reduced by modern methods the frequency, seriousness and methods of management of phlebothrombosis have been more heavily stressed in practice and in the literature. All investigators agree that thrombosis beginning in the tissues under the skin of the foot, calf and thigh is much more frequent than that arising in the pelvis.<sup>4-6</sup> Clotting begins in tissue injured by prolonged pressure of the extremity on the bed, and is not simply a

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matter of stasis. An increased clotting tendency may result from infection, from operation, or even from digitalis,<sup>6</sup> but the most important factor remains *immobilization in the recumbent posture*.

Thrombosis is the most frequently fatal sequel of complete bed rest, and the common cause of serious pulmonary complications.<sup>7</sup> *Hypostatic bronchopneumonia* is second in frequency, and is a more complex problem in which recumbency plays a contributing role of great importance. The same may be said of *acute pulmonary collapse*, an alarming but rarely fatal complication of immobility after operation.<sup>8</sup> In all of these conditions, prophylaxis and treatment have been improving steadily, so that the hazards are being reduced for patients who must be kept recumbent for many days.

Experiments carried out on healthy volunteers have confirmed the older evidence that complete bed rest causes a marked decrease in bowel activity, with *constipation* and the hazard of fecal impaction, and that it leads to *wasting*, with loss of nitrogen, potassium and phosphorus from the cellular mass of the body tissue.<sup>9</sup> Even with a high protein intake, the nitrogen balance usually is negative as long as recumbent life continues. Loss of calcium with atrophy of bone is another common effect of bed rest over long periods, but one which is apparently less marked in healthy volunteers than in sick patients. Usually there is a loss in vasomotor tone and in blood volume, which causes postural hypotension and tachycardia and a tendency to fainting when the patient finally is permitted to walk. This may disappear rapidly, or may be the beginning of a life-long tendency to vasomotor instability.

Not infrequently *inability to void properly* is a result of recumbency, particularly in older men, and occasionally this causes acute urinary retention. *Arthritic manifestations*, particularly about the neck and shoulder girdle, may result from recumbency or the awkward propped up position for reading. Patients with gout not infrequently have a brisk bout of trouble when put to bed for any cause, and not so rarely a patient experiences his initial attack of podagra when, for the first time in his life, he is confined to bed by disease or operation.

It is quite obvious that all of these common or infrequent effects of bed rest, if they do nothing else, will prolong the period of disability and weakness due to the illness or trauma which led originally to operation or to confinement to bed. Every day of complete recumbency can be thought of, not only as increasing the hazard to life, but as prolonging the period needed for rehabilitation of the body.

There is one aspect of bed rest which is of especial interest to surgeons, because to many it seems paradoxical and surprising. All surgeons are aware of the fact that recumbency, with head down and legs elevated, is useful in managing shock; that sitting up a shock case may be fatal.<sup>10</sup> They therefore are not so apt to be surprised as their medical colleagues by the fact, now fully confirmed by precise studies in many laboratories, that *the cardiac output and the work of the heart are increased by changing from the sitting to the lying position.*<sup>11</sup> The change is not negligible—it is from one-eighth to one-third the sitting level of flow. Another fact with which most laymen as well as physicians are familiar is that the tissues of the orbit often become swollen from even a few hours' recumbency. This is an evidence of the much greater rate of formation of edema in the tissues above the diaphragm when recumbent as compared to that in the erect or sitting postures.

These facts all add up to conclusions of great practical importance, amply borne out by experience. When recumbent the heart is carrying a load definitely greater than during a sedentary existence and the rate of edema accumulation in the lungs, the brain and in other tissues of the thorax and head is also greater. After an operation on the head and neck, or after trauma or a stroke, *swelling of the tissues* will occur most rapidly and to the most marked degree if the patient is allowed to lie flat; it will be minimal if he sits up with feet dependent.

*Pulmonary edema*, due to latent heart disease, to anesthetics, or to low plasma protein, will be most rapid in onset, most serious in extent, if the patient is kept flat in bed; it will be minimal while he is sitting up. Many surgeons have had the experience of seeing the onset of angina of the decubital or nocturnal type, or of a full-blown myocardial infarction, while the patient is lying quietly in bed after an operation. This usually occurs when the patient gets back on a normal (i.e. salt-rich) diet, or when much saline has been given parenterally. At autopsy in such a case, no fresh coronary thrombosis may be found, only a widespread atheromatosis of the coronaries, with perhaps an old occlusion and some old scars. In these cases, as in the many cases when the pain of myocardial infarction first becomes manifest in a person who has been asleep for some hours, it seems quite probable that edema of the succulent tissue of the atheromata has increased with recumbency, and produced an inadequate flow at a time when cardiac output and work were well above the basal level.

Bed rest, so much prescribed for *heart failure* and for *coronary oc-*

*clusion*, can itself precipitate pulmonary edema<sup>12</sup> and apparently may not prevent, perhaps may actually be a causative factor in, the manifestations of coronary insufficiency. The sitting posture is therefore particularly to be preferred after operations on patients with latent heart failure or coronary arteriosclerosis. It is my belief that most patients who are not fatigued by sitting up, who are not in shock, and whose temperatures are not over 100°, should be encouraged or at least permitted to sit up for several periods every day, as part of a program of complete rest. The length and frequency of the periods will vary with the patient's condition, in cardiac patients it is well to space these throughout the day and to have the patient sleep in a modified orthopneic position even when he is comfortable lying flat. This probably is also desirable after cerebral or cervical trauma or operations. Such patients should be in comfortable arm chairs and movement from bed to chair should be easy and deliberate.

Once again it is well to emphasize that the great strain on the circulatory system, and also on the abdominal wall, comes not from sitting or walking, but from coughing, and straining to empty the bowel or bladder. Even straining to pass gas, or to prop oneself higher on the pillow may cause greater circulatory stresses, as well as greater rise in intra-abdominal pressure, than does gently sliding out of bed and into a chair. If the sitting posture facilitates elimination and diminishes the chance of pulmonary complications it actually reduces the risk of wound hernia and cardiac strain, while at the same time promoting well-being.

¶ In *pulmonary tuberculosis*, with active apical lesions, complete bed rest may be therapeutically valuable to an extent that outweighs its disadvantages. Here the object is to avoid the low apical blood flow and lymph flow which occurs in the erect position, and to increase diaphragmatic breathing while diminishing thoracic breathing. Whether complete bed rest is really better than rest in a chair, for afebrile tuberculous patients, has not yet been established by any well planned and rigorously controlled study. On the whole, current sanatorium practice seems effective, and only a careful comparative study of cases permitted to sit up when afebrile could be justified at this time.

In every case the physician should treat bed rest with as much respect as he does digitalis, morphine, or other useful but two edged agents. Given when necessary for the patient's safety and comfort, it should be modified toward a normal way of life as quickly as possible. *Patients should never be kept in bed merely because it is convenient*

to have them there and no other therapy seems worth while at the moment. It should not be used just because the patient needs rest, and twenty-four hours in bed daily seems better than fifteen or eighteen or twenty-two, it may not be as good. There is an old saying, "Better sitting than standing, better lying than sitting," but this is not an acceptable medical adage. It is the conclusion of pessimistic misanthropy, and the last line is "Better dead than lying." Many patients come to feel this last line is true, and physicians are learning that there is truth in the paraphrase "Sooner dead if lying." The way to get patients back on their feet in good condition for a day's work is to give as little complete bed rest as possible, and to keep them out of bed except when this is the most comfortable and restful place for them during the acute stages of their illness, or during prescribed rest periods in the convalescent phase.

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## DECONDITIONING AND RECONDITIONING IN CONVALESCENCE

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THE present war has brought a revival of some appreciation of those qualities of physical "fitness" so highly prized in the Golden Age of Pericles and so generally neglected in modern times by philosopher and physician alike. It is not accidental that this revival occurred first in the totalitarian countries. Until recently we have apparently been willing to believe that the only significant aspect of fitness is a counter part of health and that health is simply freedom from disease. The importance of fitness per se has been disregarded. Much nonsense has been written and a great deal more spoken about the lack of correlation between strength and resistance to disease, about 'athletic heart' and about the 'strong back and weak brain'.

Physical educators have injured the cause of fitness for its own sake by unproven claims for the health benefits of exercise, fitness and morbidity are not closely correlated but this is no argument against fitness.<sup>1</sup> Too often the medical scientist has countered with an intellectual snobbery more befitting the classical Manchu scholar although it may be true technically that contemplative repose in a quiet room is an excellent cure for the "animal urge to exercise."

Deconditioning is simply loss of physical fitness while reconditioning may be defined as regaining fitness after it has been lost. The problem of reconditioning differs from simple conditioning only in that the starting point is frequently at a lower level of fitness and the progress of reconditioning is limited by the nature and the residues of the original cause of deconditioning. The problems are obviously both medical and social. The present discussion is based on the thesis that the responsibility of the physician is not discharged when he has simply arrested or 'cured' the disease process but that it ceases only when the patient is fully restored in all faculties. The ultimate placement of the patient in a position of maximal utility to society is a related but separate problem with which the present discussion is not concerned.

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## THE MEANING OF PHYSICAL FITNESS

The principal components of physical fitness are seen in performance in terms of *strength endurance speed and coordination*. Lindhard<sup>40</sup> pointed out that strength is most closely dependent upon the muscles per se, endurance upon the respiratory and cardiovascular systems, while coordination is most closely related to the nervous system. As S. S. Sarnat<sup>41</sup> has noted, there is an "interlocking division of responsibilities." Psychological factors cannot be ignored. Separate consideration of the several functional systems of the body is only justifiable from the standpoint of analytical convenience. Furthermore, it is impossible to make any adequate analysis of fitness in terms of effects alone. In other words, thought must be given to different systems, particularly those of the special senses. Finally, although skills themselves are not primarily parts of physical fitness, the capability of acquiring skills is undoubtedly important.

The whole problem of deconditioning and reconditioning—and that of physical fitness in general—turns on the measurement and quantitative estimation of fitness. But fitness comprises several different fundamental components and these are readily subdivided almost without limit when fitness is considered in specific situations. It is proper to ask "Fitness for what?" Clearly the emphasis on the several components should differ widely for the weight lifter, the sprinter, the marathon man and the pianist. This does not necessarily mean that specialization is impossible nor that special criteria for fitness must be established anew for every occupation or every individual. Overall indices of fitness tend to conceal the arbitrary weighting assigned to different elements but minimal standards, for all performance characteristics, in terms of such indices, may be properly demanded, with graded higher levels for the individual components adjusted to the patient and his expected role in society. Measurement should be in absolute terms but clinical evaluation demands that these be interpreted in the light of the clinical picture in the broadest sense.<sup>42</sup> In reconditioning following disease or injury the relative emphasis to be devoted to the different aspects of fitness must be decided on the basis of the particular disease or injury involved.<sup>43</sup>

Unfortunately while generalizations like the foregoing may be sound enough, it must be admitted that at present detailed and basic technical knowledge on the evaluation of fitness and reconditioning is only rudimentary. This will not be remedied simply by providing a curriculum in every small town or by elaborating propaganda for the



improvement of national fitness Research on a scale far beyond any current effort is demanded In that research the clinician the medical scientist and the physical educator must form a closely coordinated team Some of the specific problems they must face will appear in the subsequent discussion

#### THE RELATION BETWEEN FITNESS AND HEALTH

Current definitions of health are apt to be limited to the areas of applied human biology circumscribed by the present concerns of the majority of practicing physicians Attention has been limited in large part to active disease and to obvious defects of demonstrated importance in actuarial experience We have the apparent anomaly that 'unhealthy' men are the current mainstay of professional sports Jokl and Cluver<sup>4</sup> have cited notable cases of "unhealthy" but successful athletes The author has also seen numerous bad insurance risks among athletes and successful workers in industrial jobs demanding unusual physical abilities The converse situation is even more common—persons who pass all ordinary medical examinations with flying colors but who are unfit according to almost any reasonable standards<sup>7</sup>

The boundary between fitness and health is not always clear even with the most narrowly limited definitions of health Neurocirculatory asthenia is an obvious case in point, but one may wonder about the possibilities of a host of conditions which may limit the development of fitness by almost unrecognizable pathologies Neuromuscular exhaustion may be a medical syndrome,<sup>38</sup> but at what level is fatigue to be considered a reflection of unfitness which has no medical significance? In some fields, notably psychiatry, medical science does not demand evidence of obvious organic defect before action Functional incapacity of any type, including physical unfitness should be a major concern of medicine, both to detect and to treat The relation between previous fitness and the course of specific disease or recovery from disease has received very little attention worthy of classification as serious research, but the problem is both interesting and important.<sup>3</sup>

The debilitated patient is not restored to full health when he no longer needs the rather ritualistic routine of hospital bed care Deconditioning is a necessary part of many diseases, but reconditioning is not necessarily automatic when the disease has run its course In some diseases, at least, the deconditioned state favors relapse and recurrences.<sup>51</sup> Exclusive preoccupation with the disease may force deconditioning to the point of prejudice to health as recognized under any definition

Thomas and Harrison<sup>48</sup> have found that enforced inactivity is prejudicial to the recovery of rats with damaged myocardiums

### CAUSES OF DECONDITIONING

The most frequent cause of deconditioning, even in disease, is simply lack of physical activity and exercise. However, the contributions of toxic states and metabolic abnormalities are undoubtedly very important in many conditions, notably thyrotoxicosis, Addison's disease, beriberi, pellagra, scurvy and severe infections. Any conditions which tends to reduce the effective blood volume or circulation will reduce fitness, though the loss of "condition" may be only relatively temporary.

In many cases it is difficult or even impossible to distinguish cause and effect, particularly when periods of weeks or months of illness are involved. The sick person commonly is put to bed or at least restricted in activity. When activity is resumed, say a month later, the tendency is to blame his obvious unfitness on the disease process itself. There is justification in this in that many diseases are initially manifested by a general sense of weakness, vertigo, incoordination or easy fatigability. A decline in grip strength has been reported to occur before any of the ordinary symptoms of upper respiratory infection<sup>41, 37</sup>. On the other hand, cessation of activity alone, similar to that attending hospitalization in disease or injury, will rapidly result in deconditioning the disease free person. Furthermore, the progress of deconditioning in the patient can be slowed or even reversed by carefully regulated activity at an early stage of hospitalization.<sup>42, 26</sup>

Disease or injury commonly results in a loss of weight. This is simply a reflection of undernutrition or partial starvation which alone might be expected to cause a loss of apparent fitness. Actually, this factor probably tends to be overemphasized. Total starvation coupled with a high rate of energy expenditure produces marked deterioration in two or three days.<sup>47</sup> The effects of total starvation without excessive energy output are much less dramatic. Moderate undernutrition can be tolerated by normal men for months with a surprising degree of stability in physical fitness.<sup>1</sup>

### THE APPRAISAL OF FITNESS

There are three general ways in which fitness and the extent or progress of changes in condition, may be appraised. These are (1) clinical observations, (2) the patient's subjective estimate, and (3)

special tests and measurements. In practice these three merge into each other and should, in fact, be combined in reaching final conclusions.

Clinical observations of the ordinary type may permit a shrewd estimate of fitness and its changes, particularly if the physician knows his patient well. The general appearance and manner of the patient, the speed, vigor and coordination of his movements, the feel or 'tone' of his muscles and skin, together with the usual measurements of pulse rate, blood pressure, respiration and temperature, combine to form a valuable qualitative guide. This method is most useful in acute conditions and in the most severely debilitated states.

The patient's own estimate may be better than his doctor's, provided he is observant, completely objective about his own person, and coherently articulate. Unfortunately, such veritable paragons are rare and even the trained observer is limited to relative comparisons within a microcosm made up of himself and a few intimates.<sup>29</sup> Subjective testimony tends to lose validity in slowly progressive states.

Special tests and measurements theoretically offer the greatest hope to obtain valid quantitative estimates of fitness and its several components. Unfortunately, the difficulties are much greater than appear at first sight. We have discussed these in some detail recently.<sup>44, 46</sup>

In general, fitness tests fall into several categories which deserve at least brief consideration here.<sup>35</sup>

1 *Simple performance capacity* is rated in the common type of test where the patient is instructed to do something as fast or as hard or as accurately as possible and his performance is measured. The chief pitfalls in application are standardization, the skill factor and motivation. To these may be added the interpretive problem of deciding whether squeezing in an ergometer really measures general strength or whether 'endurance' in a five-minute test is really related to more general endurance, and so on.

2 *Cardiovascular (and respiratory cardiovascular) "fitness" tests* are those in which interest is confined to these functions or where it is assumed that these circulatory (and respiratory) functions are especially sensitive indicators of general fitness. Some of these are relatively easy to give and involve little motivation (e.g., those of Schneider,<sup>43</sup> Crampton,<sup>46</sup> Turner,<sup>50</sup> and Master<sup>34</sup>). Such tests measure cardiovascular and respiratory capacity or adaptation in short and rather mild strain but their predictive value for other strains so far has been rather disappointing. They tend to be unrelated to other as

pects of fitness, like strength and coordination, which cannot be ignored. The sensitivity of these tests to emotional factors is a serious handicap, in general, emotional artifacts tend to disappear when the physical strain is really severe. The cardiovascular tests seem to be rather more useful than the respiratory tests such as vital capacity, breath holding and the Flack<sup>12</sup> test.

3 *Combined cardiovascular and performance capacity*,<sup>22 14</sup> and *repeated performance capacity*<sup>13</sup> tests have been advocated recently. It is still uncertain to what extent these tests really escape the limitations of the simpler procedures while preserving their virtues.

4 *Multiform performance test batteries*, involving a series of tests covering a variety of functions, may provide results of correspondingly increased total validity. Their utility, however, is apt to be severely limited because of the facilities of space or equipment demanded, the intrusion of important skill elements or great dependence on motivation. The A A F Physical Fitness Test has been useful in the Air Forces training camps but there are no reports of extensive use with patients. The A A F test shows only a low correlation with the Harvard fitness test.<sup>16</sup> Many performance test batteries, such as those most frequently used at the Laboratory of Physiological Hygiene (cf, e.g., bibliographic reference 47) are primarily tools for research and are unsuitable for general application.

5 *Strain response tests* in general measure the departure from resting homeostasis provoked by the accomplishment of fixed tasks and the imposition of standard strains. The Schneider Index is of this nature but the principle may be extended far beyond the simple cardiovascular tests which impose only relatively small and momentary strains on a limited part of the total functional apparatus. The measured dependent variables may be pulse rate, blood pressure, respiration, oxygen transport, body temperature, reflex movements, muscle tonus, eye movements, gastric emptying, sweating rate, blood chemistry, and so on, depending on the strains imposed and the functions concerned. Tests of this type have the great advantages of objectivity, elimination of motivation and the possibilities of analysis in terms of mechanism. A major difficulty is the fact that homeostasis of the human organism is resistant to deformation except under severe strains. This means that the tests must be carefully graded according to the suspected capacity of the individual.

The detailed study of deterioration under a variety of debilitating conditions has given us clues as to the aspects of fitness most sensitive

to alteration and therefore perhaps most useful to measure in evaluating changes in the individual. Comparison of individuals may demand a somewhat different emphasis. In the individual the order of decreasing sensitivity to change seems to be roughly coordination, endurance, speed, strength. According to the experience of the Laboratory of Physiological Hygiene, this order appears to hold for deterioration produced by such diverse ways as excessive heat, starvation, deficiency of B vitamins, very prolonged physical work and bed rest. If one might attempt to translate into terms of the anatomic-physiological functions it could be suggested that the general order of increasing resistance to functional deterioration appears to be neuromuscular, cardiovascular, sensory and pure muscular. In some situations, notably hemorrhage and high temperature, the cardiovascular function is dominant. Evidence for the order of response in reconditioning is more unsatisfactory but may follow a similar pattern.

#### BED REST

Recently there has been a sudden development of interest in bed rest and its "abuse." The extensive use of bed rest and immobilization as customary parts of therapy has been questioned in general<sup>10 40 41 42 43 44</sup> and in heart disease in particular.<sup>9 18 32</sup> Something of the same question is involved in the controversy about the management of poliomyelitis.<sup>14</sup>

Bed rest is only an extreme form of inactivity in one sense but it also involves a postural change which has important hydrodynamic effects. In the horizontal position the total work of the heart and lungs may be reduced but this is not necessarily an unalloyed blessing. Apart from the potential effects on coronary circulation associated with altered pressure relations, it may be argued that proprioceptor vasomotor reflexes are needed to prevent areas of local anoxia. We have noticed the curious fact that persons in bed rest tend to present a moderate lactacidemia in comparison with those who are merely up and about. In spite of the lurid "Analyses" of the upright posture publicized by some anthropologists, it seems clear that man would be ill advised to abandon his postural customs.

Several laboratories, including that of the author, are engaged in experimental studies on the consequences of bed rest. All are agreed that in normal man bed rest rapidly produces deconditioning and that this can and should be resisted by removing the element of passive rest at the earliest possible moment. The changes in performance capacity

are accompanied by fundamental alterations of a more general nature. In our own work we have found that bed rest alone produces significant negative balances in nitrogen and potassium, a shrinkage in blood volume and considerable disturbance in vasomotor and proprioceptor adjustments. It will be noted that these changes are also characteristically seen in debilitating illness. The effects on nitrogen balance are deserving of particularly careful study.<sup>11, 39</sup>

The general picture then is that the current practice of prescribing almost indiscriminately, bed rest and then continuing this until all signs of the primary disease are gone definitely enhances deconditioning and probably delays real recovery. The physician emerges as an influential agent in deconditioning but he too often relies on nature and chance for the reconditioning of his patient.

### RECONDITIONING

No adequate discussion of reconditioning can be attempted here. Besides a lack of space there is an exasperating absence of scientific evidence suitable for practical application. It is possible however to state with certainty that remarkable success can be achieved by almost any intelligent effort patiently applied. Even persons who might be dismissed on superficial consideration as constitutionally inferior types respond dramatically to a few months of intensive rehabilitation measures (cf. e.g., bibliographic reference 25). These facts are being realized by the medical branches of our own armed forces and we may hope that more intensive efforts will result both in the uniformed services and among civilians.

As in other fields the best cure is prevention. Much deconditioning, associated with disease and injury can be prevented by avoiding all unnecessary immobilization and by instituting simple exercise at the earliest possible moment. Sitting up in bed or in a wheel chair, periodic trips to the toilet, simple hand and arm exercises are all useful at the first stage beyond absolute bed rest and in most cases can be instituted safely long before present custom. Experience has shown that natural voluntary efforts may be utilized with good success and are more pleasing to the patient than stilted calisthenics or artificial exercises. But the guidance of good clinical judgment is needed and nursing habits must be altered if satisfactory conditioning and anti-deconditioning are to be obtained.

As convalescence progresses a more vigorous program is demanded and it is here that the practitioner may be at a loss first, to decide

when the program should be intensified and, second, how to obtain such intensification with safety. It is at this stage that the patient's subjective reports and spontaneous adjustment of activity become most unreliable, and it is here that the absence of criteria is most keenly felt. It must be realized that supercaution defeats itself because enhancement of functional capacity quite generally requires that some real strain be put on present functional capacity. Exercise that is not moderately fatiguing provides little stimulus to those adaptive responses which bring about improved fitness. Infrequent bouts of brief exercise may be useless.<sup>3</sup>

Orthopedists have long used special exercises for 'conditioning' particular structures, for extending the range of motion and improving selected neuromuscular functions. These should be applied where needed, but the methods of the orthopedist are not concerned with total conditioning. Guidance as to kind, intensity and duration of exercise can be had from many discussions of exercise and physical education.<sup>17-31</sup> The lack of practical detail in these works is partly recognition of the necessity for adjusting the program to the individual patient.

In the more advanced stages of reconditioning the experienced athletic trainer can take over in spite of his lack of scientific knowledge; at present he is almost certain to be more expert in this field than the average physician. The lamentable fact is that there is a general deficiency in scientific knowledge regarding physical education. The basic principles are (1) Exercise the whole body, (2) avoid sudden and localized strains, (3) produce mild to moderate fatigue but not exhaustion, (4) adjust and graduate the program as rapidly as the patient's condition warrants it, (5) provide some exercise every day, (6) make sure the patient enjoys his reconditioning or at least does not find it a dreary chore.

Respiratory exercises have long been advocated for all stages of convalescence and training. While specific respiratory exercises have their value, many of their benefits can be achieved by means more natural and pleasant to the patient. The most effective "natural stimulus to respiration is provided by general exercise." Passive movements of the limbs reflexly induce increases of respiratory volume of the order of 50 per cent.<sup>19-25</sup> The possibilities of using carbon dioxide to induce respiratory exercise in reconditioning have not been properly explored. Local temperature changes, particularly of the skin of the face reflexly produce considerable alterations in respiration.<sup>30</sup>

Besides muscular and respiratory exercise, any discussion of reconditioning should mention diet, vascular exercise and massage. The benefits of the latter two treatments are undeniable at least in some conditions, but scientific study of them has been limited except in particular pathologies.

We have recently discussed many aspects of the relation between diet and physical performance.<sup>27-29, 29</sup> It is essential of course to correct all nutritional deficiencies which may exist, but otherwise there is no evidence to show that "super" diets are needed or even particularly useful. Vitamin supercharging and very large amounts of high quality proteins are probably neither harmful nor beneficial in the ordinary case. In many cases, however, it is necessary to give more than usual attention to appetite and stimulation of the "atonic" gastrointestinal tract which often results from a period of illness.<sup>21</sup> It is significant that Ivy and Grossman<sup>21</sup> state: "The best means for increasing gastric tone and motility is physical exercise."

#### SUMMARY

1 Physical fitness is important for its own sake to the individual and to society. It may also be significant in resistance to disease and injury, but there is no close dependency of morbidity on fitness.

2 Deconditioning and reconditioning refer to loss and restitution of total physical fitness which comprises strength, endurance, speed and coordination. The total bodily physiology contributes to these items but the muscular, cardiovascular, neuromuscular and nervous systems are primary.

3 It is impossible to dissociate fitness from health by any fixed definition, fitness should be considered a component of total health. Disease and its treatment tend to produce deconditioning and this state may be prejudicial to recovery.

4 Bed rest of itself produces marked deconditioning involving metabolic, proprioceptor and cardiovascular abnormalities as well as loss of fitness. Common practices of medical treatment tend to accentuate deconditioning but serious efforts should be made to correct this.

5 The appraisal of "condition" or physical fitness is difficult and the present state of knowledge is deficient. Clinical observations, the patient's subjective estimate and special tests and measurements should all be employed.

6 The first attack on deconditioning should be to prevent or minimize its occurrence. Under careful supervision it is usually advantage



ous to bring the patient quickly to a graduated program of activity. Exercise should be adjusted to produce some fatigue but not exhaustion.

7 A good and liberal diet is important and special attention should be given to appetite appeal for the convalescent. Vitamin supercharging and "super" diets are of unproven merit except in special cases of real nutritional deficiency.

8 It should definitely be a part of medical responsibility to restore the patient to full health and fitness as well as to remove or cure the primary disease or complaint.

9 Controlled experimental research on a large scale is badly needed in the whole field of fitness and of deconditioning and reconditioning.

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## ADDITIONAL ARTICLE

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### BILATERAL ARTIFICIAL PNEUMOTHORAX

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BILATERAL artificial pneumothorax for the treatment of pulmonary tuberculosis was first demonstrated by Ascoli in 1912. When we consider that about 80 per cent of patients admitted to most sanatoria have bilateral advanced tuberculosis, it is easy to see how important bilateral pneumothorax therapy has become.

In administering bilateral pneumothorax it is essential that the phthisiotherapist give special consideration not only to his selection of cases but to the physiology of respiration and its relation to the cardiovascular system.

In bilateral pneumothorax we aim to obtain a selective collapse, that is to say, the greatest degree of collapse is noted over the affected area. This condition is brought about by the decreased elasticity of the infected lung tissue and compensatory emphysema of the normal lung tissue.

The chief *indications* for this form of treatment are bilateral progressive disease in which the lesion occurs in the upper lobes; bilateral progressive disease in which the lesion may be basal on one side and apical on the other; spread of disease or reactivation of disease in the contralateral lung, and uncontrollable hemoptysis from the contralateral lung.

The main *contraindications* to this form of treatment are extensive bilateral disease; acute tuberculous pneumonia; when effective collapse

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TABLE I—STATISTICS ON BILATERAL PNEUMOTHORAX IN FIFTY-TWO CASES

No	Name	Sex	Age	Color	Pneumo- thorax	Pneumon- olysis	Final Sputum	Complications	Results	Remarks
1	J A	M	33	W	R 3/34 L 4/37	R 4/36	Neg	None	Orderly	None
2	H H	F	23	W	R 2/34 L 10/34	R 6/34	Pos	Fluid R	Died at home	O R A A 3/38
3	M M	F	38	W	R 12/35 L 11/38	L 4/36	Neg	Fluid L Spont pneumothorax R	In hospital	Doung well
4	F D	M	20	W	R 1/35 L 6/36		Pos	Obliterative pleuritis L after 42 months Obliterative pleuritis L after 24 mos	Home 2/39	O R A A
5	B W	F	22	C	R 8/35 L 6/36	R 11/35	Neg	None	Home 2/36	Working
6	F M	M	26	W	R 11/35 L 6/37		Pos	Fluid L Obliterative pleuritis R after 22 mos	Home 2/40	O R A A
7	G L	M	25	C	R 4/35 L 4/35		Neg	Fluid R Obliterative pleuritis R after 19 mos	Home 12/39	O R A A
8	J M	M	29	W	R 1/35 L 5/36	R 4/35	Neg	None	Home 9/36	Working
9	K S	F	23	W	R 12/35 L 1/37	R 3/36	Pos	Diabetes mellitus	Died at home 4/39	O R A A 12/38
10	J McD	M	29	W	R 4/35 L 12/35		Pos	Empyema L Amyloid dis	Dead 11/38	Post mortem
11	T T	F	29	W	R 7/35 L 1/36		Pos	Empyema L Amyloid dis	Dead 1/38	
12	M S	F	32	W	R 8/35 L 11/35	R 10/35	Pos	Amyloid dis	Dead 8/40	Post mortem
13	G R	F	29	W	R 8/36 L 11/35		Pos	T B Larynx T B catentitis	Dead 1/40	Post- mortem
14	L M	F	25	W	R 10/35 L 10/35		Neg	T B larynx T B catentitis	Dead 5/39	
15	J L	M	19	W	R 3/36 L 11/35		Neg	Fluid R	Home 1/37	O R A A
16	M G	F	33	W	R 11/46 L 3/42	R 2/37	Pos	Fluid R	In hospital	Condition fair

17	A G	I	23	W	R 8/36 L 7/37	R 1/37	Neg	None	Home 11/38	Working
18	M McD	I	26	W	R 4/36 I 8/36	L 1/37	Neg	Obliterative pleuritis R after 33 months	Home 10/39	Working
19	G R.	I	35	W	R 8/36 L 10/36	L 1/37	Pos	Spont pneumothorax L	Dead 11/37	Doing well
20	A G	I	26	W	R 4/37 L 3/42	I 10/37	Neg	Empyema L	In hospital	Doing well
21	R A	I	30	W	R 9/37 I 9/42	R 12/37	Neg	Fluid L	In hospital	Working
22	M M	F	18	W	R 8/37 I 2/39	R 2/38 L 3/39	Neg	None	Home 8/40	Working
23	B M	I	24	W	L 4/37 R 6/38	L 7/37 R 12/38	Neg	None	Home 5/39	Working
24	A K	I	25	W	R 5/37 L 1/40	R 8/37 R 3/38	Neg	Fluid R	Home 6/41	Working
25	M B	I	26	W	L 9/37 R 1/38	L 4/38 R 8/38	Neg	Fluid L	Home 5/39	Working
26	E N	I	18	W	L 11/37 R 2/38	R 1/39 L 3/39	Neg	Obliterative pleuritis I after 26 mos	Home 9/39	Doing well
27	R C	M	27	W	R 11/37 L 7/39	L 4/37 R 9/37	Pos	Empyema L	Dead 2/42	
28	C H	F	24	W	R 4/37 L 7/39	R 10/37 L 3/38	Pos	Empyema L	Dead 6/41	
29	E W	M	17	W	L 12/37 R 7/39	L 12/38 L 9/37	Pos	Empyema L Amyloid dis	Dead 2/40	
30	R G	M	24	W	R 4/37 I 10/38	L 4/37 R 10/38	Pos	Fluid R Obliterative pleuritis R after 17 mos	Home 6/40	Doing well
31	G B	M	36	W	R 4/37 L 4/38		Pos	Spont pneumothorax R Empyema R	Dead 8/40	
32	D S	I	23	W	R 9/38 L 8/42	R 1/39	Neg	T B Larynx None	In hospital	Doing well
33	E H	F	32	W	R 3/38 L 10/40	R 5/38 L 4/39	Neg	None	In hospital	Doing well

TABLE 1—Continued

No	Name	Sex	Age	Color	Pneumo- thorax	Pneumo- cylisis	Final Sputum	Complications	Results	Remarks
34	C A	F	26	W	R 2/38 L 10/38	R 5/38 L 4/39	Neg	None	Home 6/39	Doing well
35	M E	M	45	W	R 1/38 L 6/39	R 3/39 L 4/40	Neg	None	Home 5/41	Working
36	G G	M	39	W	R 10/38 L 12/38	R 8/40 L 2/41	Pos	Spont pneumothorax I	Home 9/41	O R A A
37	T O	M	22	W	R 3/38 L 2/39		Pos	Empyema I	Dead 6/41	Post mortem
38	M C	M	45	W	R 8/38 L 11/38		Pos	Empyema R T B enteritis	Dead 3/40	
39	F D	F	26	W	R 8/39 L 11/40	R 9/39 L 1/42	Neg	None	In hospital	Doing well
40	J B	M	22	W	R 12/39 L 6/41	R 4/40 L 9/41	Neg	Fluid L	In hospital	Doing well
41	J D	M	26	W	R 11/39 L 2/42	R 1/40	Pos	Fluid R	In hospital	Condition fair
42	E C	F	20	W	R 8/39 L 4/40	R 11/39 L 7/40	Neg	None	Home 10/40	Working
43	R D	F	34	W	R 2/39 L 3/41	R 6/39	Pos	Spont pneumothorax L Fluid L	Dead 2/41	
44	L B	F	21	W	R 8/39 L 1/40	R 10/39	Neg	None	Home 2/41	Doing well
45	A I	F	21	W	R 11/39 L 12/40	R 1/40	Pos	Empyema R	Dead 3/42	
46	N C	F	26	W	R 6/40 L 9/42	R 4/41 L 12/42	Neg	Fluid L	In hospital	Doing well
47	J B	F	24	W	R 8/40 L 1/41	R 11/40 L 5/41	Neg	None	Home 6/41	Working
48	P H	M	26	W	R 12/40 L 1/41	R 3/41 L 5/41	Pos	Empyema I	Dead 8/41	

49	J O	M	19	W	R I 2/40	L 7/40	Pos	Diabetes mellitus	Home 3/41	O R \ \
50	H C	F	29	W	R I 5/40	L 7/42	Neg	Spont pneumothorax R	Home 7/42	Working
51	C D	M	20	W	R I 2/42	L 7/41	Pos	None	In hospital	Doing well
52	J I	M	22	W	R I 12/42	L 9/41	Neg	None	In hospital	Doing well

O R \ \ — O on request against advice



is impossible of the initial lung, a lowered vital capacity below 1800 cc, the weight of the patient being considered, patients over forty five years of age, anyone with heart disease, asthma and emphysema

In all of our cases bilateral pneumothorax was carried out successively rather than simultaneously, that is to say, the more affected lung was collapsed first After partial reexpansion of the primarily treated lung and depending on the patient's vital capacity, collapse of the contralateral lung was instituted

The physician should know at all times the degree of collapse of both lungs, hence the frequent use of the fluoroscope and the roentgen ray films The patient's vital capacity should be recorded every several weeks

When a bilateral collapse is brought about and a moderately high negative pressure is maintained on both sides a normal balance between the respiratory and circulatory systems is kept A positive pressure should never be employed on both sides as this will undoubtedly lead to a lowered vital capacity and hence varying degrees of dyspnea At times a positive pressure may be maintained on one side so long as the contralateral lung does not show more than about 40 per cent collapse The two sides should not be inflated on the same day when the bilateral treatment has been instituted but bilateral re-fills on the same day are safe once collapse on both sides is stable and well maintained

#### ANALYSIS OF FIFTY TWO CASES OF BILATERAL PNEUMOTHORAX AT THE BOSTON SANATORIUM

From 1934 to 1942 inclusive, a series of fifty two patients after careful selection were submitted to bilateral artificial pneumothorax The series consists of thirty-one females and twenty one male patients the youngest of whom was 17 years and the oldest 45 years old, the average age of the group being 25 years All these patients were white with the exception of two Negroes Every patient presented a positive sputum at the onset of his treatment either at the start of the unilateral or at the time of the bilateral pneumothorax

Bilateral pneumothorax was administered just as long as collapse was necessary and was producing benefit

Many of our patients required a pneumonolysis on one or both sides to sever offending adhesions Out of our series of fifty two cases thirty-eight patients or 74 per cent underwent a total of sixty pneumonolyses, which were unilateral in twenty one and bilateral in sev-

enteen patients One patient (No 35) had a two-stage pneumonolysis both on the right and left sides Two patients (Nos 22 and 24) had a two-stage pneumonolysis on one side in addition to a single pneumonolysis on the contralateral side Two patients (Nos 26 and 29) had a two-stage pneumonolysis on one side

TABLE 2—SUMMARY OF STATISTICS ON BILATERAL PNEUMOTHORAX

	Cases	Per Cent
Total number of patients treated	52	
Number of female patients	31	60
Number of male patients	21	40
Average age of patients	25	
Positive sputum at onset of treatment	52	100
Sputum conversion	28	53
Total number of pneumonolysis operations	60	
Patients having pneumonolysis	38	74
(a) Patients having unilateral pneumonolysis	21	56
(b) Patients having bilateral pneumonolysis	17	44

It is interesting to note that fourteen out of seventeen patients on whom bilateral pneumonolysis was performed are alive Nine of this group are working and five are still in the hospital under treatment.

Complications—Bilateral pneumothorax is more than twice as difficult to carry out as unilateral collapse, consequently, the fullest co operation on the part of the patient is essential The more important complications confronting the physician and surgeon are effusions, spontaneous pneumothorax, obliterative pleuritis, extension of disease,

TABLE 3—COMPLICATIONS IN BILATERAL PNEUMOTHORAX

	Cases	Per Cent
Total number of cases treated	52	
Pleural effusions	26	50
(a) Serous effusions	15	29
(b) Tuberculous empyema	11	21
Obliterative pleuritis	7	13
Spontaneous pneumothorax	6	12

marked dyspnea due to a lowered vital capacity, and gastrointestinal disturbances especially when collapse of the left lung is instituted

Twenty-six patients or 50 per cent developed effusions which required thoracentesis Fifteen of these patients had a serous effusion while eleven developed a tuberculous empyema Six patients or 12 per cent developed a spontaneous pneumothorax

Seven patients or 13 per cent developed an obliterative pleuritis after the respective lung had been collapsed anywhere from seventeen to forty-two months.

We were able to convert the sputum of twenty-eight patients or 53 per cent.

**End Results.**—Of the total number of patients treated, seventeen or 33 per cent are dead. Of the twenty-one male patients treated seven are dead, and of the thirty-one female patients, ten are dead. It is interesting to note that about one third of each group died. Postmortem examinations were performed on five cases. Thirteen patients or 25 per cent are still in the hospital under treatment.

TABLE 4—RESULTS OF BILATERAL PNEUMOTHORAX

	Cases	Per Cent
Total number of cases treated	52	
Total number of deaths	17	33
Total number in hospital	13	25
Total number at home	22	42
Total number of postmortem examinations	5	30

Twenty-two patients or 42 per cent are home. Of this group six left the hospital against advice, and sixteen are home and well and most of them are working.

We are of the opinion that the results obtained in this series have been very encouraging and definitely indicate that the procedure is effective and safe.

#### CASE REPORTS

The following case illustrates the management of a patient with progressive disease involving both upper lobes.

**CASE 1 (No. 34).** C.A., a white woman, aged 26, first noted symptoms in May 1937. Her father had died of pulmonary tuberculosis. On admission to the Sanatorium the patient had a positive sputum and a sedimentation rate of 16 diagonal line (Cutler method). Roentgenograms showed bilateral infiltration of the upper lobes with bronchopneumonic reaction and cavitation (Fig. 231).

On February 10, 1938, artificial pneumothorax was instituted on the right side. Because of the presence of adhesions a pneumonolysis was performed on May 20, 1938. Artificial pneumothorax was begun on the left side on October 20, 1938, with the patient having a vital capacity of 1000 cc. (the patient's weight at this time being 115 pounds). Due to apical adhesions a pneumonolysis was performed on April 26, 1939 (Fig. 233). Two months after this procedure the sputum became negative and has remained so ever since.

This patient was discharged on June 27, 1939 weighing 155 pounds. Her sedimentation rate was 6 horizontal line and the vital capacity was 2100 cc.

The patient at the present time receives about 350 cc of air bilaterally on the same day once a week. Her vital capacity at present is 2300 cc.



Fig 232

Fig 233

Fig 232 (Case 1)—Infiltration and bronchopneumonic reaction involving upper one third of both lung fields. Multiple cavities in both upper lobes.

Fig 233 (Case 1)—Bilateral partial pneumothorax.

The following case is presented to illustrate the management of a patient with unilateral pneumothorax and progression of disease in the contralateral lung.

**CASE II (No. 47)**—In the case of J.B., a white woman aged 24, the onset of symptoms occurred in March 1940. On admission to the Sanatorium the patient had a positive sputum and a sedimentation rate of 27 diagonal curve. Roentgenograms showed infiltration with cavitation at the left apex, cloudiness of the left base, and slight amount of infiltration in the right second interspace (Fig. 234).

On August 8, 1940, artificial pneumothorax was begun on the left side. Because of the presence of adhesions a pneumonolysis was performed on November 20, 1940. Two months later the patient had a bronchopneumonic process involving the right upper lobe (Fig. 235). With a vital capacity of 2100 (the patient's weight being 134 pounds) and partial reexpansion of the left lung, artificial pneumothorax was started on the right side January 13, 1941. Owing to the presence of adhesions a pneumonolysis was performed on May 30, 1941 (Fig. 236). One month later the sputum became negative and has remained so ever since.

Fig 234

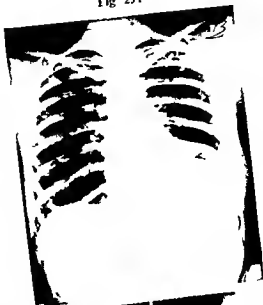


Fig 235

Fig 236

Fig 234 (Case II) —Infiltration and bronchopneumonic reaction involving left upper lobe and left base. Cavity in first left interspace. Minimal infiltration second and right interspace.

Fig 235 (Case II) —Partial pneumothorax of the left lung. Infiltration and bronchopneumonic reaction involving right upper lobe.

Fig 236 (Case II) —Bilateral partial pneumothorax.

This patient was discharged on June 13, 1941 weighing 152 pounds. Her sedimentation rate was 11 diagonal line and her vital capacity 2300 cc. The patient at the present time receives about 300 cc. of air bilaterally on the same day once a week. Her vital capacity is 2500 cc.

The next case is presented to show the treatment of a patient with unilateral pneumothorax and uncontrollable hemoptysis from the contralateral lung.

CASE III.—E.C., a white woman, aged 20, first noted symptoms in January 1939. On admission to the Sanatorium the patient had a positive sputum and a sedimentation rate of 23 diagonal curve. Roentgenograms showed bilateral infiltration and multiple small cavitation involving the upper lobes particularly the left (Fig. 237).



Fig. 237.

Fig. 238.

Fig. 237 (Case III).—Infiltration and bronchopneumonic reaction of both upper lobes with multiple cavities.

Fig. 238 (Case III).—Bilateral partial pneumothorax.

On August 28, 1939, artificial pneumothorax was instituted on the left side. Because of the presence of apical adhesions a pneumonolysis was performed on November 1, 1939. In April 1940 the patient had several hemoptyses ranging from 1 to 4 ounces. From the physical examination it was thought that the hemorrhage was coming from the right side. Despite the low vital capacity of 1500 cc. (weight of the patient being 118 pounds) artificial pneumothorax was begun on the right side. After two refills the patient stopped bleeding. Because of apical adhesions a pneumonolysis was performed on July 10, 1940 (Fig. 238).

One month later the patient's sputum became negative and has remained so ever since. The sedimentation rate dropped to 10 horizontal line.

The patient was discharged October 24, 1940, weighing 126 pounds. At present she is working and well. Bilateral air refills of 250 cc. are given once weekly on the same day. Vital capacity at the present time is 2100 cc.

#### SUMMARY AND CONCLUSIONS

1. Fifty-two cases of advanced pulmonary tuberculosis were treated by bilateral pneumothorax.

2. *Pneumonolysis* was performed on thirty-eight patients, twenty-one of whom had a unilateral pneumonolysis and seventeen a bilateral pneumonolysis.

3. The most frequent complications encountered were serous effusion in fifteen cases, tuberculous empyema in eleven, spontaneous pneumothorax in six, and obliterative pleuritis in seven.

4. Sputum conversion was brought about in twenty-eight cases.

5. Of the group seventeen patients are dead, thirteen are still under sanatorium care and twenty-two are discharged.

6. Cases submitted for bilateral pneumothorax should be carefully selected.

7. Noncooperative patients responded least well to this form of therapy.

8. Bilateral pneumothorax is a valuable and effective form of treatment for certain cases of advanced pulmonary tuberculosis.

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The  
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of  
NORTH AMERICA

LAHEY CLINIC NUMBER

PHILADELPHIA AND LONDON

W. B. SAUNDERS COMPANY

1945

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5

# THE SURGICAL CLINICS of NORTH AMERICA

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LAHEY CLINIC NUMBER

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## SYMPOSIUM ON GYNECOLOGIC SURGERY

### THE TECHNIC OF TOTAL AND SUBTOTAL HYSTERECTOMY

FRANK H. LAHEY

WHILE much of the literature coming from this Clinic has had to do with such surgical problems as involve general surgical procedures dealing with the esophagus, thyroid, stomach, gallbladder, colon and rectum, and so forth, because of the fact that gynecology has never been separated from general surgery here there has always been a very large number of gynecologic problems with which to deal. As everyone knows, gynecology plays no small part in the total field of abdominal surgery. It is because of this that we have always had a very large number of hysterectomies, total and subtotal.

As a result of this experience with hysterectomy done in large numbers, standardization of methods as with other surgical procedures has taken place, and as a result of this it seems worth while to present these standardizations. As with subtotal gastrectomy, subtotal thyroidectomy, esophageal diverticulectomy and other procedures, the technic of total and subtotal hysterectomy is the result of constant changes with added experience and now represents somewhat near the accepted procedure in this Clinic.

**Anesthesia**—The selection of anesthesia for hysterectomy has always seemed to me of the utmost importance. Since all operations in the Clinic below the level of the nipple are done under spinal anesthesia, the decision here is but which drug to employ. In this connection we like nupercaine because it gives adequate length and because, being lighter than spinal fluid, it permits placing the patient in Trendelenburg position quite promptly.

We have no argument to make for spinal anesthesia. We know the debates that have occurred concerning spinal anesthesia. I wish only

to make a provision which I have repeatedly made and that is if spinal anesthesia is given by someone who is expert in its administration then proof is to be found in the several thousand which we have given in this Clinic with but one neurologic complication and no death over the years and it has the very great advantage of providing adequate relaxation quiet intestinal contents and very desirably contraction of the bowel rather than distention.

I think as will be stated regarding length of the incision if all surgery can be done under the following desirable conditions it can be better done with the quiet abdomen that comes with good spinal anesthesia with the wide exposure that comes with incisions of adequate length and with the visualization which comes with better than the average light provided in the average operating room.

**Preliminary Diagnostic Dilatation and Curettage and Pelvic Examination under Anesthesia**—Not so many years ago at a round table conference at one of the postgraduate teaching seminars held in a distant part of the country I was asked this question: What should one do with the cervix after a subtotal hysterectomy has been done and the pathologic report comes back showing carcinoma of the body of the uterus? I can well recall that my reply to the question was to the effect that the best treatment in such a situation was to have done a preliminary diagnostic dilatation and curettage with immediate examination of the scrapings and then the cervix would have been removed at the time of the hysterectomy and the problem would not arise.

In discussing hysterectomy total and subtotal it is trite but nevertheless necessary to call attention to the fact that never in this Clinic is a hysterectomy done without a preliminary diagnostic dilatation and curettage and a preliminary pelvic examination under the anesthetic to check the diagnosis originally made. Two distinct advantages result from such a precaution: (1) there will be rare but definite instances in which the preliminary pelvic examination under an anesthetic will fail to bear out and confirm the one made at the Clinic, or in one's office. No one who has had much experience with pelvic examinations will be unwilling to admit that particularly in nervous women who are unable to relax themselves and in those women with thick abdominal walls there will at times be doubt as to the exact findings at pelvic examination and (2) as already has been stated one will occasionally be surprised to find adenocarcinoma of the fundus without symptoms or carcinoma within the cervical canal which does not demonstrate itself either by symptoms or by visualization of the cervix through the speculum.

I feel very sure as a result of so many years' experience with

pelvic examinations that the plan which we have pursued here has been well worth while, and that is, when there is the slightest doubt about a pelvic examination it should be done under a good general anesthetic, with permission at the same time to do a diagnostic dilatation and curettage, and if necessary, abdominal operation.

It again, I am sure, must seem presumptuous to those who have had a large experience with diagnostic dilatation and curettage to speak of the danger of *perforation of the uterus*. Yet I am sure that there is no one who has had a large experience with diagnostic dilatation and curettage who has not perforated a uterus. It is very necessary to bear in mind that this hazard increases directly with the advancing years of the patient. The small, atrophic, senile uterus of advanced years can be perforated so easily that one hardly knows that the curet has passed through the wall into the general peritoneal cavity. Likewise, it is well to remember that in introducing sounds through the cervical canal into the uterus, painstaking gentleness with never any rough handling is necessary. With angulations of the cervical canal, any attempt to force sounds or probes into the uterine canal can readily perforate the back or front wall of the uterus at the point where the cervix joins the uterus.

**The Incision**—As relates to the abdominal operation, the incision is of utmost importance. I have repeatedly said that in the upper abdomen the extension of the upper end of the incision as high as possible without bringing it in contact with the ribs is of the greatest importance, and with incisions particularly in the midline of the lower abdomen, the extension of the incision as low as possible without barring the pubis is likewise of the greatest importance. Most of these points are directly related to the adequateness of the exposure at its most desirable point.

If there is one thing that I personally have learned about abdominal surgery, it is that the disadvantages of long incisions are more than compensated for by the added exposure and thus added safety that go with them. Surgery which can be visualized and can be exposed to good light is infinitely safer than surgery done through inadequate incisions with poor light and poor exposure. An operation can be technically difficult enough with some of the conditions which must be met in the pelvis even with the most adequate exposure and can be made doubly difficult when one attempts to conduct these procedures through limited incisions.

We, therefore, have always assumed that in extensive dissections of the pelvis an incision from the midline to the umbilicus is not adequate. As shown in Figure 239, we have extended our incision to the left

of the umbilicus, leaving a good sheath of rectus between the midline and the incision, separated the rectus muscle from the midline, pushed it to one side and thus have retained a good strip of rectus fascia at the level of the umbilicus with which to restore the abdominal wall.

One of the difficulties that confronts everyone in midline incisions for hysterectomy is finding the exact middle line. Many times I have seen my assistants waste too many minutes dissecting the sheath of the rectus muscle, searching for the midline. This is solved very simply by carrying the incision straight down in the middle line to the pubis, by separating the fascia of the rectus until the pyramidalis on either side is found. It will point to the middle line and at once indicate where the incision in the midline is to be made.

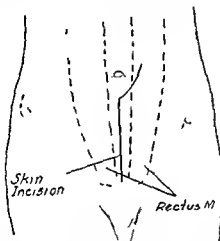


Fig. 239.—Note the method of swinging the midline incision to the left of the umbilicus at some distance in order to preserve a good strip of the anterior sheath of the rectus muscle with which to make the reconstruction.

There are one or two other points concerning the midline incision for hysterectomy. The peritoneum should always be opened high. One never knows with large fibroids how high the bladder has been carried up over the lower portion of the incision, and it is therefore very much safer to open them nearer the level of the umbilicus, at which point the bladder cannot be present. With the peritoneal cavity then opened, the bladder can be palpated and the peritoneum incised downward without danger of opening into the bladder.

As related to abdominal incisions, one can to advantage remember the proposal of Dr. Donald Guthrie and that is that patients who are to have pelvic operations be placed in moderate Trendelenburg position early in order that their intestines may gravitate away from the pelvis and thus avoid the necessity of rough handling.

**Walling Off the Intestines**—With the abdominal incision complete and the peritoneal cavity well open, the omentum can to great advantage be used as a walling off material. It is pulled down, placed over all of the small intestines as an apron and over this strips of warmed gauze are placed to hold the intestines out of the peritoneal cavity. This is a very much superior method of walling off the intestines from the pelvis as compared with the placing of gauze pads directly upon the loops of small intestines.

**Determining the Course of the Ureter in Intraligamentous Fibroids**—With the peritoneal cavity well open and exposed the pelvic cavity can be visualized and one can determine the location of the fibroid if it be a fibroid or the extent of the malignancy if it be a carcinoma. With fibroids one can determine whether they are intraligamentous. If so, it is important at once to determine whether or not the course of the ureter on either side is over the intraligamentous fibroid or under it. The ureters are usually under such fibroids, but occasionally are over those arising low from the side of the cervix. One can determine whether or not the fibroids are beneath the bladder and whether or not they spring so low from the cervix as to make ligation of the uterine artery on that side at its origin necessary.

**Question of Removal of Tubes and Ovaries**—With the pelvis visualized and the fibroid grasped with double hooks or ice tongs as one chooses the decision is now made as to whether or not the tubes and ovaries will be removed with the uterus. I have assumed that if a patient has five or more years to go without a probable menopause, it is desirable to leave both or one ovary. If, on the other hand, the menopause, assumed to be at approximately forty-eight or forty-nine years will occur in three years, we have undertaken in such cases the removal of both tubes and ovaries, together with the uterus.

**Preliminary Ligation and Severing of the Round Ligaments**—Having settled this problem, I believe the most important single step to make hysterectomy for fibroid easy is the preliminary ligation and severing of the round ligaments (Fig. 240). When this is done, in many instances it will permit immediate delivery of the fibroid uterus well up into the wound so that the uterus hangs only by its attachment to the pelvic wall by the ovarian vessels and to the vagina by the cervix. It is true that in most instances the round ligaments have been so stretched out as the fibroid has developed that they do not bind the tumor filled uterus in the pelvis. On the other hand there are many instances in which strong, well developed round ligaments have not stretched out and attempts to deliver the fibroid uterus from the pelvis are limited by the shortness of these ligaments. I feel very strongly



that the preliminary ligation and severing of the round ligaments, even though they are adequately long is a very desirable first step in hysterectomy.

With the round ligaments then severed and the uterus delivered, as shown in Figure 240, provided the tubes and ovaries are to be removed, the ovarian vessels, as shown in Figure 241, can now be tied on the

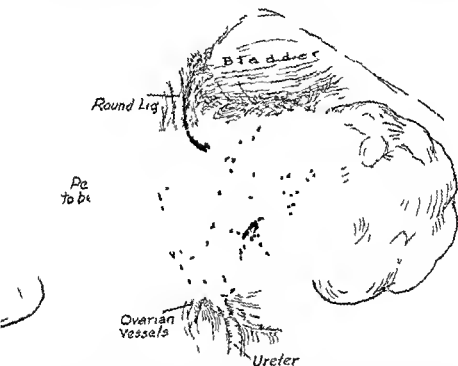


Fig. 240 In this drawing is shown preliminary ligation and severing of the round ligaments to permit mobilization and delivery of the fibroid uterus. As a rule the round ligaments are sufficiently long so that this is not necessary but occasionally they are so short that severing them greatly facilitates the operation. It will be noted also that as the round ligaments are severed the attachment of the tubes and ovaries to the horn of the uterus is represented by a pedicle which is easily ligated when it is desirable to preserve the tube and ovary. Note the dotted line showing the incision which will be made in the peritoneum over the front of the cervix and bladder.

pelvic wall and the broad ligament severed up to each side of the uterus. This permits immediate delivery of the uterus containing its fibroids so that it literally hangs by its cervical attachment to the vagina.

**Wiping the Bladder Down from Anterior Wall of Cervix and Vagina —** With these steps completed, the next important step is to sever the peritoneal reflection over the top of the bladder onto the wall of the

uterus, and to wipe the bladder down from the anterior wall of the cervix and vagina until it is well below the level of the lower point of the cervix as it rests within the vagina (Fig. 241).

This step is, I believe, one of the most important procedures in hysterectomy. We have repeatedly had patients sent to us with vesico-

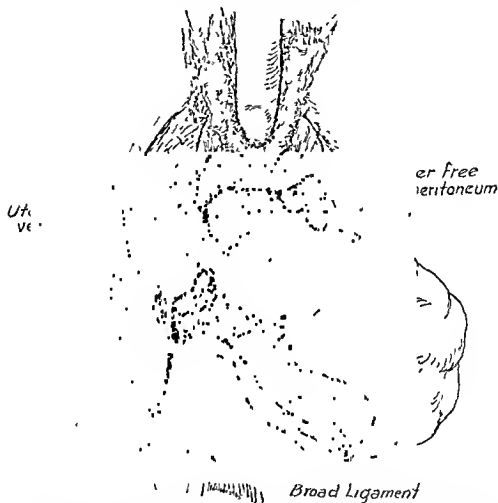


Fig. 241—Note in this drawing that the ovarian vessels have been ligated in order to remove the tubes and ovaries with the fibroid uterus, that the peritoneum over the front of the cervix and the bladder has been incised and that the bladder has been so wiped down with gauze on the finger that the whole front of the cervix is exposed

vaginal fistulas for repair which I am sure are the result of failure to wipe the bladder adequately off the front wall of the cervix and vagina, with the result that when the round ligaments, as shown later in Figure 245, are sutured into the stump of the cervix, the adherent bladder on the front wall of the cervix is caught in the stitch, resulting in the typical high vesicovaginal fistula.

With the bladder well wiped down and the posterior cervical attachments in subtotal hysterectomy above the uterosacral ligaments likewise cut and wiped down attention is then directed toward controlling the lower blood supply of the uterus where the uterine vessels enter on the sides of the cervix.

**Visualization of the Ureters in Subtotal Hysterectomy**—With preservation of the cervix in subtotal hysterectomy it has never been necessary in our experience to dissect and visualize the ureters as they

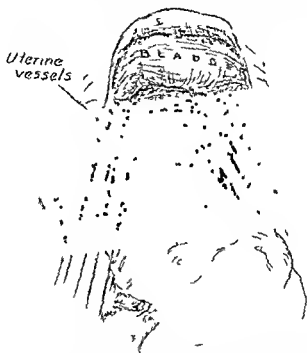


Fig. 247—In this illustration the bladder has been well wiped down at the front of the cervix. The point of the transection of the cervix is shown by a dotted line and two Ochsner clamps have been obliquely applied to the uterine vessels on either side of the cervix.

pass beneath the uterine vessels. In every hysterectomy, however, the ureters are visualized as they run along the pelvic wall beneath the peritoneum. If one has any doubt about their presence, they can usually be demonstrated by wiping them gently with a small wad of gauze in the mouth of a hemostat which will stimulate their vermiform motion and demonstrate their identity. They can be picked up in the fingers and rolled easily with the loose parietal peritoneum as it is attached to the pelvic wall, and likewise their course demonstrated. Unlike total hysterectomy, however, we do not believe that their

complete dissection and exposure in subtotal hysterectomy is necessary.

**Control of the Blood Supply**—With the lateral wedges of tissue well wiped down to the side of the uterus, the uterine arteries can now be seen running upward on the side of the cervix, and they can be grasped by Ochsner clamps, placed high and in the oblique position, as shown in Figure 242. It is extremely important that these Ochsner clamps grasp the uterine vessels well up to the side of the cervix. The vessels are then cut on either side between the clamps and one is then ready to sever the cervix.

**Objections to Total Hysterectomy for Fibroids**—There have been frequent discussions, debates and differences of opinion on the part of gynecologists and general surgeons as to whether or not total hysterectomy should always be done in cases of fibroids. It has always been my opinion that it should not be done and for the following reasons, if we place the advantages on one side and the disadvantages on the other. Total hysterectomy is done largely against the possibility of carcinoma occurring in the remaining cervix. If one takes the lowest reported probable figures of carcinoma incidence in the remaining cervical stump at 2 and the highest at approximately 7, I do not believe that this risk outweighs the fact that the suspension of the vagina and pelvic floor is less dependable and satisfactory when the cervix has been removed than when the round ligaments can be sutured into the cervix. In addition to that there arises a very delicate question, difficult to discuss and difficult to obtain a satisfactory answer, and that is the effect of shortening the vagina in a married woman during her active sex life.

I find it extremely difficult to debate this subject in public when adherents to the plan of total hysterectomy in benign lesions during active sex life say that it does not shorten the vagina. After all, who can say that it does not? We can be sensitive and shy about discussing sex problems, but after all, satisfactory sex life between husband and wife is an important thing, and what husband after his wife has had to go through a serious operation such as total hysterectomy is likely to proclaim to anyone that her vagina is or is not shortened?

It seems to me always that as we debate this subject we have the incidence as stated already on the one hand of possible malignant degeneration still capable of being treated by operation or by radiation, and on the other hand the infinitely superior support to the pelvic floor, bladder and vagina with the cervix retained and added advantage of a completely full length vagina.

I have but one other argument to offer against total hysterectomy

and it is that when prolapse does occur after total hysterectomy, it really represents eversion of the vagina, does not permit any very satisfactory method of suspension, and can often be cared for only by obliteration of the vagina. This is not the case when the cervix is retained. Even though there is failure of the round ligaments to support and hold the uterus, a further suspension can in practically all cases be accomplished.

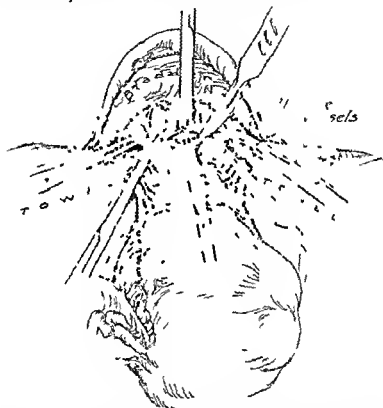


Fig. 243.—The incision in the front of the cervix at the line marked by dashes in Figure 242 has now been started. It is of such a character as to wedge out most of the contained cervical canal.

**Submucous Enucleation of the Cervix**—Some years ago I published a method of coning the cervix by submucous enucleation of the cervix.<sup>1</sup> I am sure that this was never intended by me to be presumed as an original procedure but merely as a method that I have found practical. For a time we gave up this method because of a number of vaginal hemorrhages which occurred as a result of incomplete control of the vessels within the coned cervix. Dr. Cattell has continued to employ the method and we have resumed its use again in moderation, taking greater pains to control the bleeding within the cervix.

One can see from Figures 243 and 244 that by this method it is possible to get out a considerable part of the cervix, particularly the cervical canal, and that it has also the additional advantage of deep implantation of the round ligaments making even more secure support.

It is important if this operation is done to introduce deep stitches well into the body of the cervix to control bleeding within the canal (Fig. 245).

As a preliminary step to the severing of the cervix, as shown in Figure 243, I have found it useful to so fold a towel that its angle

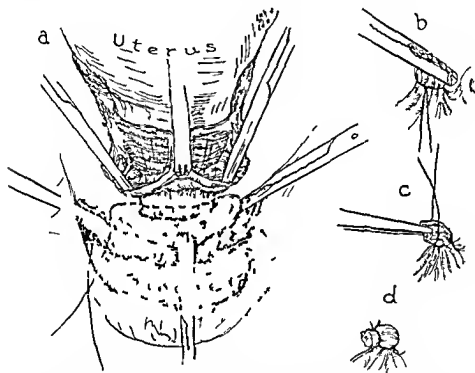


Fig. 244—The method of enucleating the cervical canal within the cervix as the cervix is amputated is shown in this illustration.

The method of ligating the uterine vessels is also shown. In *b*, *c*, and *d* note the method of turning in the stump after the first tie to so angulate it that the tie cannot pull off.

can be placed well down behind the cervix in the pouch of Douglas to wall off the rest of the pelvis well around the sides. This is but a small step but has proved useful to me.

As shown in Figures 243 and 244, as the incision is made in the cervix the immediate introduction of double hooks, front and back, can lift the cervix, evert the edges and make the enucleation by coning of the cervix easier.

**Ligation of the Uterine Vessels**—I wish particularly to call attention to a method of ligation of uterine vessels. While I am sure that a

and it is that when prolapse does occur after total hysterectomy it really represents eversion of the vagina does not permit any very satisfactory method of suspension and can often be cared for only by obliteration of the vagina. This is not the case when the cervix is retained. Even though there is failure of the round ligaments to support and hold the uterus a further suspension can in practically all cases be accomplished.

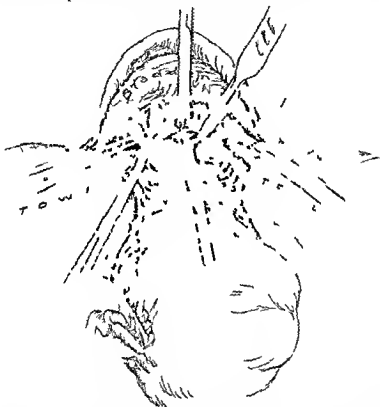


Fig. 243.—The incision in the front of the cervix at the line marked by dashes in Figure 242 has now been started. It is of such a character as to wedge out most of the contained cervical canal.

**Submucous Enucleation of the Cervix**—Some years ago I published a method of coning the cervix by submucous enucleation of the cervix.<sup>1</sup> I am sure that this was never intended by me to be presumed as an original procedure but merely as a method that I have found practical. For a time we gave up this method because of a number of vaginal hemorrhages which occurred as a result of incomplete control of the vessels within the coned cervix. Dr. Cattell has continued to employ the method and we have resumed its use again in moderation, taking greater pains to control the bleeding within the cervix.

round ligaments into the stump of the cervix are never carried out onto the side of the cervix. There is a considerable variation, as everyone knows, in how close the ureters run to the lateral walls of the cervix, and to place stitches through the round ligaments and other than directly through the top of the cervical stump is to risk the hazard of transfixing a ureter and producing which I have once done a ureterovaginal fistula.

Great pains should be taken to control all the oozing within the broad ligaments and particularly on top of the reflected bladder and between the bladder and the anterior wall of the vagina and cervix, from which the bladder has been wiped down. Undesirable hematomas

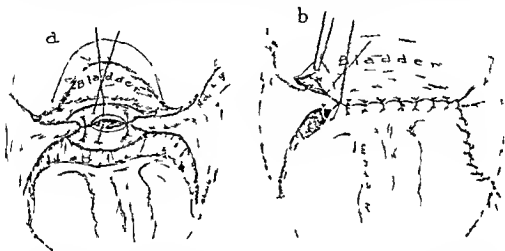


Fig 246—In *a*, is shown the final closure of the cervix after the enucleation of the canal. All but the last two stitches are tied. In *b* is shown the method of closing the pelvic peritoneum starting at the right covering the stump of the ovarian vessels and with interrupted sutures bringing the peritoneal flap from over the bladder back to meet the peritoneal flap reflected from the rectum. Note the small aperture to be left on either side from which oozing or hematoma should it occur can escape into the peritoneal cavity.

can occur here as a result of failure to control meticulously the venous oozing which is profuse at this point and can result in postoperative bladder disturbances which are avoidable (Fig 246).

**Total Hysterectomy**—To turn now to the difference in technic in total hysterectomy, done in my hands only for malignant disease, the steps are very much the same except that in this lesion one does not debate whether or not the tubes and ovaries will be left in. Because of the advantages in terms of nonrecurrence with removal of the tubes and ovaries and because of the danger of extension into these structures, the tubes and ovaries are always removed in all malignant lesions. With the pelvis well exposed, again as a first step in the pro-



cedure, the round ligaments are ligated and severed. The ovarian vessels close to the pelvic wall are ligated and severed. The peritoneum between the round ligaments and the ovarian vessels is freed and the ureters are now demonstrated in the cellular tissues in the broad ligaments. The ureters are followed down to the side of the cervix and the front wall of the bladder is wiped down and off the lateral wall

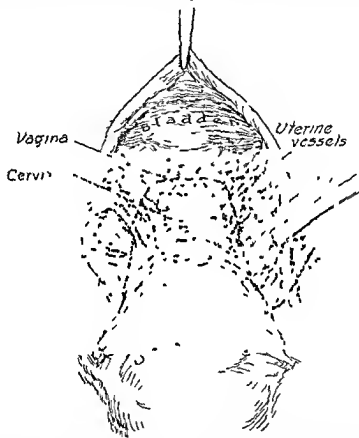


Fig. 247—In this illustration is shown the method of dealing with the uterine vessels and ureters in total hysterectomy. Note exposure of the uterine vessels well out to their origin and demonstration of the ureters as they pass beneath the uterine vessels and enter the bladder. Note that the bladder has been well wiped down beyond the end of the cervix and onto the anterior vaginal wall.

of the cervix until the uterine vessels can be demonstrated as individual structures. The uterine vessels are dissected well back to their origin and the ureters are demonstrated as they pass beneath them. The uterine vessels are tied well out close to their origin and clamped on the cervical side, severed between the tie and the clamp, and the ureters demonstrated completely in their course beneath the uterine

vessels well up to the point where they enter the bladder. Parametrial vein oozing at this point is often extensive and frequently troublesome. It is meticulously controlled, the parametrium is wiped well down on the lateral wall of the vagina, the vagina is exposed in front well below the lowest point of the cervix in order that it can be clamped

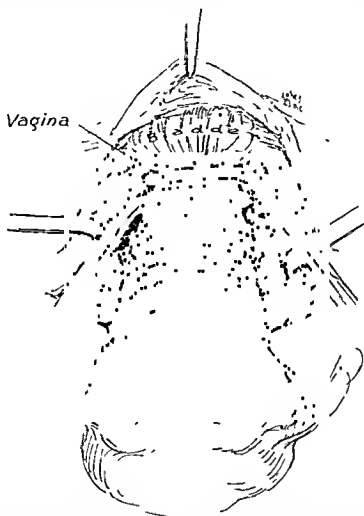


Fig. 248—In this illustration is shown application of the two right angle clamps below the cervix on the upper end of the vagina and between which the vagina is cut and sterilized. Note the ureters dissected well down to their entrance into the bladder and safely retracted laterally in order that they may not be caught in the right angle clamps applied to the vagina.

across, the uterosacral ligaments are severed, clamped and tied in back, and the peritoneum and posterior attachments to the posterior wall of the vagina likewise are wiped well down. If the lateral parametrium is adequately dissected and wiped well down from the lateral walls of the vagina, the vagina will be represented largely by an elongated tube, as shown in Figure 247. The ureters can be seen

throughout their entire course through the parametrium and their point of entrance into the bladder will be well demonstrated. The ureters will have been separated well outward so that clamps can easily be applied to the vaginal wall.

Our experience with this procedure has not been inconsiderable not only with hysterectomy for carcinoma of the uterus but also with abdominosacral removal of the rectum for carcinoma. We have now done combined abdominosacral removal of the rectum together with combined Wertheim hysterectomy, removing in addition to the rec-



Fig. 249—In this illustration is shown the method of plicating the crossed round ligaments over the top of the sutured vagina and, as shown in Figure 246, the pelvic peritoneum will be closed by continuous sutures laterally and interrupted sutures over the top of the vagina to completely peritonealize the pelvis.

tum, the tubes, ovaries, uterus and often most of the vagina in lesions of the rectum which have become adherent to the posterior aspect of the uterus or vagina in seventy cases. We have learned as a result of this experience how necessary it is to dissect the ureters up to their point of entrance into the bladder, to wipe the bladder so thoroughly down over the front of the vagina and to so separate the ureters that they can be pulled well to either side in order that the two clamps can be applied, as shown in Figure 248, to the vagina without danger of grasping the ureters in their tips.

Again in this situation I have found it valuable to introduce a folded

towel, as shown in Figure 243, against the possibility of slipping of the clamps and discharge of vaginal or uterine contents

With the vagina severed across and its ends cauterized either with the actual cautery or with carbolic acid and alcohol, the vagina is now sewed over and over the clamp, the clamp removed and the stitch again carried back across the vagina to insure its safe and complete closure and also to control oozing from the cut edges of the vaginal mucosa

The problem now arises as to how best to suspend the vagina. We have placed the round ligaments across the top of the vagina overlapping one against the other, as shown in Figure 249 sewed these over with interrupted chromic catgut stitches and have then completely closed the pelvic peritoneum over the entire structure

It has rarely been necessary to introduce drains and then only when we have been unsuccessful in controlling the oozing in the endometrium or beneath the bladder

**Closure of the Pelvic Peritoneum**—In both total and subtotal hysterectomy it is important to recall that the ureters as they pass along the pelvic wall are quite closely adherent to the pelvic peritoneum, that the ureters are very often close to the outer edge of the incision in the pelvic peritoneum as the broad ligament has been cut. One must be careful as the pelvic peritoneum is closed by continuous 00 catgut suture that the needle does not inadvertently penetrate a ureter in its position adherent as it is to the lateral pelvic peritoneum

I wish to give a word of warning in closure of the pelvic peritoneum, particularly in subtotal hysterectomy. We have always left an aperture on either side of the flap of peritoneum covering the bladder which is brought over the uterine stump. Should there be any accumulation or oozing beneath this peritoneum this procedure leaves an aperture out of which the fluid can drain into the general peritoneal cavity and not accumulate as a hematoma beneath the peritoneum and over the bladder, which may later produce frequency and pressure upon the bladder and occasionally necessitate secondary drainage

Closure of lower abdominal wounds presents few problems. The peritoneum is lax, the fascia is strong and there is usually such little difficulty in making an adequate closure that discussion of this point seems unnecessary.

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## FIBROMA OF THE OVARY

Review of Twenty two Cases at the Lahey Clinic,  
1927 to 1945

SAMUEL F. MARSHALL AND LEE ROGERS, JR

FIBROMAS of the ovary are uncommon but not rare tumors. They form irregular, firm, white or yellowish white tumors which vary in size from 1 or 2 cm. in diameter to much larger masses. Ewing stated that they may reach enormous dimensions. More commonly, they are small, infrequently produce symptoms and often are found incidentally during abdominal operations for a pathologic condition elsewhere than in the pelvis or at postmortem examination.

The literature on fibromas of the ovary prior to 1937 is small in volume and articles have appeared sporadically. The main interest in this ovarian tumor before that time lay in its unusualness and its infrequency. In 1937, Meigs and Cass stimulated renewed interest in fibroma of the ovary by reporting ovarian fibromas associated with ascites and hydrothorax, and suggested that this syndrome be distinguished from malignant disease of the ovary. This triad of fibroma of the ovary accompanied by ascites and by hydrothorax has since been given the name of Meigs' syndrome, and most of the literature on fibroma of the ovary since 1937 has been devoted to this particular condition.

This paper comprises a study of twenty two patients with fibroma of the ovary seen at the Lahey Clinic since 1927, however, seventeen of the twenty two cases were found between 1932 and 1944. All of these tumors have been verified by pathologic examination. Such a review illustrates the comparative infrequency of this type of tumor. Moreover, a study of the twenty-two cases failed to produce any case with ascites and hydrothorax accompanying the fibroma of the ovary (Meigs' syndrome). One case presented the characteristic picture, and fibroma of the ovary with ascites and pleural effusion was suggested in the diagnosis, but unfortunately this patient did not return for further study after the initial examination, and all efforts to ascertain her subsequent course have failed. Of the twenty-two cases reviewed, in only four was the diagnosis of fibroma of the ovary made or suspected before operation and in fifteen the tumor was an incidental finding at pelvic or other abdominal operation. In three cases the fibroma was discovered at necropsy.

The first mention of ovarian tumors in the literature is accredited to John Astruc in Paris, in 1740. Baillie, in 1799, next mentioned fibromas of the ovary by stating that they resembled uterine fibroids, and Boivin, in 1837, stated that these fibrous tumors are sometimes attached to the ovaries as well as to the uterus. In 1845 Kiwisch mentioned finding solid tumors of the ovaries. Peaslee, in 1872, in his book on ovarian tumors discussed fibroma of the ovary as arising from the corpus luteum and stroma of the ovary. Leopold, in 1876, was the first to make a special investigation of the subject since Virchow. He reported fifty nine cases in the literature, to which Coc added twenty cases in 1882. Peterson, in 1902, reviewed eighty-two cases in the literature and added two. In 1914 Tullerton stated that many of the cases previously reported may have been sarcomatous since pathologic study had been inadequate. Hellman, in 1915, quoted Aschoff in stating that only 2 per cent of all ovarian tumors are fibroids. Tullerton had previously reported the incidence of 1.5 per cent according to Schroder and 2 to 3 per cent according to Pfannenstiel. Hoon, in 1923, reported the cases at the Mayo Clinic and gave the incidence as 3.5 per cent of all cases of ovarian tumors. Caylor and Masson, in 1930, quoted the series of Rohdenburg which gave an incidence of 4.6 per cent. In 1937, Meigs and Cass reviewed the literature on fibroma of the ovary with regard to its association with ascites and hydrothorax. At that time only six such cases were found. Since this article was published, much emphasis has been placed on this triad of symptoms and the importance of distinguishing it from the other more common causes of ascites and hydrothorax. Rhoads and Terrell in 1937, are credited with giving the name, Meigs syndrome, to this triad and it has been repeatedly stressed that exploration of the abdomen should be undertaken to rule out the presence of this benign lesion, fibroma of the ovary, as the cause of ascites and pleural effusion rather than a malignant lesion. By 1943, Meigs, Armstrong and Hamilton had increased the number of cases reported in the literature on fibroma with ascites and hydrothorax to twenty seven cases. In this report they gave Tut credit in 1892 for first advocating abdominal exploration of cases with abdominal and chest fluid on the grounds that these signs did not always mean cancer.

#### ETIOLOGY

From a study of the literature, the etiology of fibroma of the ovary has been attributed to a number of causes, none of which have been definitely proven. It has been attributed by many investigators<sup>11-14</sup> to hemorrhage into the ovary, to an inflammatory source, to mechanical factors, bacteria, scirrhotic effect from retrogressive changes at the

menopause, and to chemical action. Wyne stated that it may develop from scar following a previous ovarian operation.

Aschoff and Hoon stated that the origin of this tumor is uncertain, and Hellman agreed but went further to say that it must arise from connective tissue. The connective tissue is found in the stroma, corpus luteum, corpus fibrosum, organizing blood clots and in the capsule of the ovary. Hoon mentioned the similarity to keloids, but stated that fibromas do not recur as do keloids. In disagreement with Hellman, Crile stated that some writers suggest that fibroma originates from epithelial tissue, and that the rapid growth and age incidence are best explained on this basis.

#### PATHOLOGY

The pathologic changes in cases of fibroma of the ovary are no different from those of fibromas elsewhere in the body. Titus discussed three distinct types and these have been generally accepted in the literature. According to him, the first type is a true hyperplasia of the



Fig. 250—Bilateral fibromas of the ovaries removed at operation. The tumors were firm and hard and were not malignant.

ovary, with the ovarian tissue obliterated entirely. In the second type there is only partial involvement of the ovary. This fibroma is usually encapsulated and is analogous to a uterine fibroid. The third type is a pedunculated fibroma arising from the ovary by means of a pedicle. It is this third type which produces the acute symptoms resulting from torsion or twisting of the pedicle.

Grossly, the lesions may attain varying sizes, may be soft to hard depending on the amount of fibrous tissue present and the presence of degeneration (Fig. 250). The color depends on the contents, the tumor is whitish or yellowish white if it contains only a little blood, and brownish to red if it contains much blood. The specimen may be nodular but usually the contour of the ovary is retained.

Ewing stated that the structure of fibromas varies greatly in the cells or vessels. There may be admixture of myoma and secondary change may produce myxoma, osteoma and chondroma; necrosis may produce cystic degeneration.

On cross section, fibromas of the ovary have a whitish, glistening surface, with interlacing bands and whorls of fibrous tissue (Fig. 251), according to Reel. Microscopically, the predominant cell is a fibroblast. It is a spindle-shaped cell with the nucleus pointed and/or slightly bent and a large amount of chromatin present. There may be areas of calcification, hyaline and fatty changes, edema or cystic formation, the cysts supposedly resulting from liquefaction following anemia

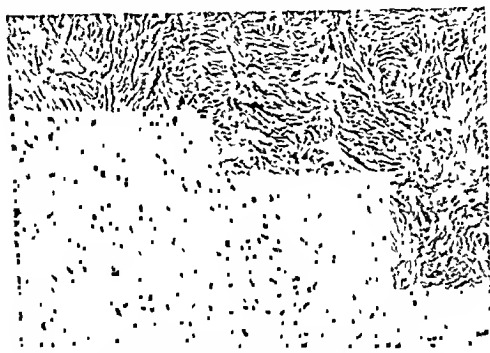


Fig. 251.—Cross section of tumor shown in Figure 250. Note predominance of interlacing bands and whorls of fibrous tissue.

from circulatory changes in the ovary. Some muscle strands may be present which makes it difficult at times to distinguish the fibroma from a myoma.

Malignant degeneration may occur but is rare. Fullerton said it is no more uncommon than malignant degeneration in the uterus and is usually sarcomatous in nature, while Meigs<sup>29</sup> quoted Johnson as saying that malignant degeneration is more frequent in fibroma of the ovary than in uterine fibroids. It can be distinguished from sarcoma, which is the most likely type of malignant change, by its appearance in women in an older age group, by its slower growth, by the absence of mitotic figures and embryonal cells, and it is less cellular than a



sarcoma. It is more difficult to distinguish it from a spindle cell sarcoma but the lack of extension of a fibroma into the surrounding tissue may be helpful in making the diagnosis.

Crite in discussing the small group of rapidly growing fibromas with ascites and pleural effusion stated that the clinical and pathologic findings are entirely at variance since clinically they seem malignant and pathologically appear benign and never recur after removal. This fact stimulated the theory that perhaps these fibromas were actually of epithelial rather than of connective tissue origin.

#### CLINICAL FINDINGS

The signs and symptoms associated with fibromas are variable and are in no way diagnostic. Only when ascites and hydrothorax are present can one suggest the diagnosis of fibroma of the ovary when pelvic examination reveals the presence of an ovarian mass. Even then malignant disease is the more probable diagnosis until the nature of the pathologic process arising in the ovary is proved at operation. The

TABLE 1—AGE OF PATIENTS AT TIME OF DISCOVERY OF FIBROMA

Age Years	No. of Cases
20-29	1
30-39	3
40-49	4
50-59	9
60-69	4
70-79	1

findings in the twenty-two cases reviewed at the Lahey Clinic have been summarized and are compared with those reported in the literature.

**Race**—According to the literature fibromas arise predominately in the white race with only an occasional report of a case in the Negro race. All of the patients reported in this series were white women.

**Age**—Of the twenty-two patients the age range was from twenty-seven to seventy years. Eight patients were in the age group twenty-seven to forty-nine years and fourteen were from fifty to seventy years. Thus a majority were in the older age bracket (Table 1). Owen reported a case at the age of twelve and one at the age of seventy-three years but the average is in the fourth and fifth decades about the same as in cases of uterine fibroids.

**Social State and Fecundity**—Eighteen of the twenty-two patients had been married thus the tumors were about four times more frequent in married than in single women. Reports in the literature vary some

writers reporting the tumors as more frequent in single women and others as twice as common in married women. Pregnancy was found to increase the likelihood of fibroma only slightly. Twelve patients had had one or more pregnancies, nine had never been pregnant, and in one case a report of pregnancy was not made. Catamenia was variously affected. In only two cases were the periods regular, in three cases they were irregular and in four cases no record of the periods was found. The remaining thirteen patients had undergone menopausal change. The ages of these thirteen patients ranged from thirty-nine to fifty-one years, thus showing that the onset of menopause was not particularly affected by the fibroma (Table 2). Peterson reported that 49 per cent of his series had regular menstrual cycles and stated that fibromas delayed the menopause. Hoon, Doran, and Titus agreed that menstruation is seldom affected, but McIlrath, Meigs,<sup>1</sup> and Bernstein showed that it was altered by fibromas.

**Symptoms.**—Pain was a variable symptom. Pelvic pain not of the ordinary type which accompanies menstruation occurred in four cases

TABLE 2—ONSET OF MENOPAUSE

Age Years	No. of Cases
30-39	3
40-49	9
50-59	3

and abdominal pain was associated in nine cases. It was in no way suggestive of ovarian tumor. Abdominal swelling, which is a frequent complaint according to the literature, was present in only one of the twenty-two patients. Pain as a symptom can usually be traced either to torsion of a pedunculated fibroma or to adhesions around the lesion.

Symptoms such as diarrhea, constipation, and frequency of urination were almost negligible and seem from the literature to increase proportionately with the increase in the size of the fibroma. Danforth reported a fibroma complicating pregnancy in one case in which the tumor had to be removed for fear of obstructing labor.

Pelvic examination revealed the presence of a mass in the pelvis in thirteen cases with negative findings in four cases. The pelvic examination was not recorded in three cases and was not done in two cases, the tumors being found incidentally during laparotomy or at postmortem examination.

**Meigs' Syndrome.**—Although this syndrome has been a much emphasized finding, only in the past eight years, Cullingworth first mentioned it in 1879. Before it was described by Meigs undoubtedly a diagnosis of inoperable malignant disease was made in many cases,

two of these patients were operated on because of a pelvic mass. In three cases the fibroma was an incidental finding at necropsy which was performed for conditions not related to the pelvis. In the remaining four cases the diagnosis was made at the time of other intra-abdominal surgical procedures, namely, Miles resection for carcinoma of the rectum, loop colostomy for inoperable carcinoma of the rectum, cholecystectomy, and gastroenterostomy. In all cases the diagnosis was proved by microscopic examination.

### TREATMENT

Surgical excision, with removal of the ovary involved, is the only treatment. This is an absolute necessity because of the danger of malignant degeneration even though it is slight, and to prevent or cure the ill effects of associated ascites and hydrothorax. These tumors are benign and do not recur. On removal of the fibroma, the ascites and pleural effusion, if present, entirely disappear in a short time. The mortality is in accord with other pelvic operations and the procedure should not be hazardous.

At operation in our twenty-two cases, bilateral tumors were found in one case (Fig. 250), in eight cases the fibroma involved the right ovary and in nine the left ovary. In four cases it was not stated which ovary was involved. There was no regularity about the site of involvement. In seven cases the entire ovary was involved, in nine cases the ovary was only partially involved and in four cases pedunculated fibromas were present. In two cases the nature of the lesion was not described.

The tumors ranged in size from 1.5 cm. to 12 cm. In the literature the range varies from mere granules to the size of a man's head, with the weight being as much as 60 pounds.

No unusual associated pelvic pathologic conditions were noted in any of these twenty-two cases, although the literature<sup>9, 16</sup> records tuberculosis of the tube present with a fibroma of the ovary and also a fibroma of the labium majus. Other cases<sup>23</sup> have been reported in which there is associated malignant disease of the same and/or opposite ovary together with the fibroma.

The prognosis with operative intervention is excellent.

### CONCLUSIONS

Fibroma of the ovary is relatively uncommon. The incidence varies from 1.5 to 3.5 per cent of all ovarian tumors. Twenty-two cases are reported in this paper. The tumor is benign, rarely becomes malignant and does not recur following surgical removal.

These tumors occur predominantly in the white race, usually in the fourth and fifth decades, and their presence does not alter the onset of the menopause

The symptoms are variable and in no way pathognomonic, in a large percentage of the cases a diagnosis was not made and the fibroma was found incidental to other surgical procedures

Meigs' syndrome, the presence of ascites and hydrothorax with fibroma, has not been adequately explained but it is important to distinguish it from other conditions causing fluid, especially ovarian malignant disease

Surgical intervention is followed by complete cure, with no recurrence and with disappearance of the ascites and pleural effusion when present This is especially important in those cases of fibroma in which a diagnosis has been made of inoperable malignant disease

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## MANCHESTER-FOTHERGILL OPERATION FOR PROLAPSE OF THE UTERUS

C C ENGLEMAN

THE Manchester Fothergill operation, or broad ligament plastic procedure, is one of the older procedures employed in the treatment of uterine prolapse, and still has a wide field of usefulness. It may be employed during the child-bearing age or after the menopause, it lends itself to combination with other operative procedures when they are indicated. It will usually correct adequately a moderate degree of prolapse at any age.

The anatomical basis for the operation rests on the fact that the broad ligaments constitute the most powerful intrapelvic support for the uterus. The lower portions of the broad ligaments adjacent to the uterus (sometimes referred to as the cardinal ligaments) constitute fairly well defined bands of fibrous muscular tissue, readily accessible from below. These tissues as utilized in the operation serve to elevate the uterus and what is equally important, perhaps, though not often stressed, maintain the cervix in the posterior part of the pelvis. It has been emphasized repeatedly in the past that the "normal" position of ante flexion of the uterus offers an important protection against the development of prolapse, whereas retrodisplacement with weakening of the cervical supports enables the force of gravity to aid in the direct descent of the uterus down the vaginal canal.

Dilatation and curettage are first carried out routinely. Some degree of cervicitis is ordinarily present. It is usually necessary to perform amputation of the cervix. We wish to point out that it is undesirable to perform too high an amputation of the cervix as a routine, for the uterus will receive better support from the pelvic floor if some length of cervix projects into the vaginal vault, to rest on the repaired perineum. Otherwise there is a definite tendency for the cervix to swing downward and forward again, leading to recurrence of the prolapse.

The anterior vaginal wall is opened by making a transverse incision through the mucosa just above the cervix, and extending it forward in the midline by scissors dissection nearly to the urethral meatus. The incision is then curved down about the cervix posteriorly. Lateral mucosal flaps are pushed back widely. The bladder is separated from the cervix below by careful sharp dissection of the fibers binding the

two structures together and then pushing the bladder well up on the uterus by gauze wiping. If a cystocele is a conspicuous feature it may be dealt with by two rows of infolding sutures in the pubocervical fascia if this fascia is not detached from the bladder wall, otherwise,

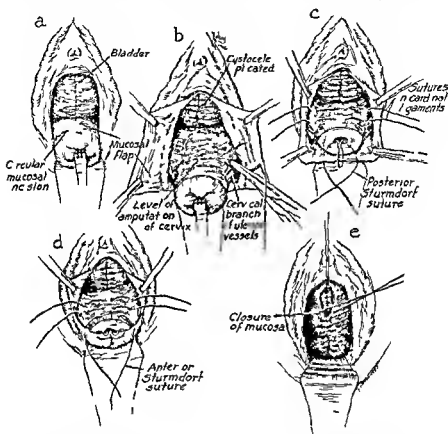


Fig. 252—*a* The cervix is grasped with tenaculum and drawn down. Dotted line shows incision in mucosa. A complete circular incision is made about the cervix preliminary to its amputation.

*b* The bladder has been dissected upward and plicated with fine catgut sutures. The cervical branches of the uterine vessels are ligated and cut preliminary to amputation of the cervix.

*c*, Sutures are placed in the cardinal ligaments and left untied until Sturmdorf sutures are inserted in the amputated stump of cervix.

*d*, The placing of the anterior Sturmdorf suture is demonstrated.

*e* After tying the sutures in the cardinal ligaments the mucosal flaps are approximated with interrupted sutures starting at the cervix.

the fascia may be split from beneath the mucosal flaps and sutured before approximating the mucosa.

Two heavy clamps, one on either side, are placed nearly at right angles to the uterine canal at the level of the line of amputation. These

clamps grasp the cervical branches of the uterine artery. The lower half inch or more of cervix is then amputated with a knife without much bleeding. The amount of cervix amputated depends, of course, on the degree of elongation of the cervix and the extent of lacerations and of cystic cervicitis. The cervical vessels are secured with chromic sutures on either side and the clamps are removed. The mucosal flaps are drawn into the newly formed cervical os, covering the freshly amputated stump of cervix either by means of Sturmdorf sutures or by simple infolding mattress sutures as desired.

The next essential step of the operation is the suturing of the cardinal ligaments. Some surgeons detach the ligaments from either side of the cervix and unite them across the midline in front of the cervical stump. Others introduce the sutures from the vaginal side of the flap, going through mucosa, picking up the cardinal ligament on one side, taking a bite for anchorage on the anterior surface of the stump, and continuing the same suture to the opposite side, picking up the cardinal ligament and then bringing the needle out through the mucosa, when the suture is tied the knot of course, is on the outside. We prefer to leave the ligaments uncut but pick up the cardinal ligament, staying beneath the mucosal flap. The suture is introduced first on the left side, then catches the anterior wall of the cervical stump at a slightly higher level and drops back to the original level to catch the tissue on the right side. Two such sutures may usually be placed and held separately in clamps until ready to tie. The redundant vaginal mucosa is then cut away, taking a triangular portion from each side. The cervix is pushed well inside the vagina and the deep cardinal ligament sutures are tied to support the uterus in this position. The vaginal flaps are sutured with interrupted stitches. This suture line should be begun at the cervix and carried toward the urethra, otherwise an unnecessary strain is placed on the newly united supporting ligaments. The mucosal flaps should be sutured to the underlying uterine wall below and the pubocervical fascia above in order to minimize the dead space in the wound and to produce proper arching of the interior vaginal wall.

If it is decided to combine this operation with the Watkins Wertheim interposition operation, the latter is carried out after the deep sutures in the cardinal ligaments have been placed but before they are tied.

The final stage of the operation is the performance of high perineorrhaphy. A vaginal pack is inserted to be left in twenty-four hours and the bladder is drained by an indwelling catheter, preferably a Foley catheter with a 30 cc bag.



Postoperative infections of the urinary tract are minimized by employing sulfanilamide solution, 0.8 per cent, for bladder irrigation, and administering 2 gm. of sulfathiazole per day by mouth, together with liberal fluid intake, while the catheter is in place. If the catheter is removed in six days the patient usually will void normally. Periodic catheterization must, of course, be performed until the residual urine has decreased to an ounce or less.

## PRESENT STATUS OF THE WATKINS-WERTHEIM INTERPOSITION OPERATION

FRANK H LAHEY

WE have now been employing the Watkins-Wertheim operation for a good many years and have done it in 260 cases. Applied to the proper cases, and carried out with the proper technical steps, it has been one of the most satisfactory operations which we have used. It is important, however, to obtain good results with this procedure to limit it to the cases in which it is indicated, not to try to stretch beyond these points, and to carry out the technical steps in it with painstaking care.

The principle of the Watkins-Wertheim interposition operation is that the interposition of the fundus of the uterus between the completely freed bladder and the anterior wall of the vagina acts as a support and a pessary to overcome the cystocele effect upon the bladder. This is brought about (1) by the presence of the rounded uterine body beneath the bladder and (2) by the suspension effects of the round and broad ligaments on the bladder, resting as it does literally on the top of the fundus.

One may readily see from these statements that the ideal case for the employment of the Watkins-Wertheim interposition operation is the patient with a cystocele whose cervix still remains high, with good round ligaments and good broad ligaments suspending the cervix in its normal position, and that the poorest case for the application of this operation is that with a complete procidentia in which the cervix is not suspended and if interposed beneath the bladder will merely descend again as but a part of the procidentia.

Obviously, there are all modifications between the ideal case in which the uterus is well suspended and remains in its normal position with a marked cystocele and those cases in which there is partial descent of the cervix. There are even those cases of moderate procidentia in which the fundus of the uterus may be interposed beneath the bladder, a round ligament suspension done and a high perineorrhaphy with a quite satisfactory result, but the application of this operation in patients in whom the bladder, uterus and rectum have descended together is a futile one.

One of the questions that will arise in everyone's mind who has not made use of this operation is, what are the effects upon urination and

the patient's comfort with the fundus of the uterus being placed beneath the bladder. After having done, as previously stated, 260 of these operations we can say with assurance that if the bladder is completely separated and if the case is a proper one there will be no undesirable effects.

#### SELECTION OF CASES

After the experience which we have had with these cases we have learned that there are certain things that one must have in mind. Obviously, the one of first importance is that the proper case must be selected. One should be certain that previous pelvic operations have not been performed such as the type which fixes the fundus of the uterus either to the abdominal wall or binds it in the retroperitoneal position by adhesions so that it cannot be readily delivered through the peritoneal incision which is made where the peritoneum is reflected over the anterior surface of the uterus and the posterior surface of the bladder. In addition to this, one must be careful of course, that fibroid tumors do not exist of such size as likely to prevent the delivery of the uterus through the small opening which is made in the peritoneum between the uterus and the bladder. It seems unnecessary to state but must be said that precautions must be taken to be certain, by means of preliminary curettage and diagnostic biopsy, that adenocarcinoma is not present in the fundus.

In the large experience which we have had with these cases, it does not seem possible that it would occur but there have been two patients sent to this Clinic for management of a pregnancy on whom this operation had been done elsewhere while the patients were within the childbearing period without careful obliteration of the fallopian tubes. I can think of no complication which can be more serious than a pregnancy in a uterus which has been placed underneath the bladder. This, of course brings up the question of the decision as to whether or not one should employ this operation during the childbearing period. If it is to be employed it is obviously essential that a procedure adequate in character which will insure the nonoccurrence of pregnancy must be undertaken, such as a wide resection of segments of the fallopian tubes with inversion of the ends beneath the peritoneum after ligation with black silk.

Again it seems unnecessary to include inflammatory lesions of tubes and ovaries as a contraindication for this operation because the undesirability of performing this operation with such associated lesions is self-evident.

If this operation is undertaken in the presence of a badly lacerated or ulcerated cervix or in the presence of cystic disease of the cervix,

the decision should be made very definitely at the time of the operation to take care of the cervix by amputation or cauterization because after the uterus has been inserted under the bladder the cervix will so point backward and the perineum will have been built so high that any later procedure on the cervix will be difficult. For that reason in any such condition of the cervix as mentioned previously, we have always included amputation of the cervix, together with interposition of the fundus of the uterus, when such conditions are present.

There have been suggestions at times that the implantation of the fundus of the uterus underneath the bladder and the fixation of the fundus to either side of the urethra would have some beneficial effect upon those patients who have urinary incontinence. We have applied this procedure in several cases but found that there is very little to be expected in the way of added control in patients who, following childbirth, have had inability to hold their urine. This condition is much better treated by a direct approach than by the indirect approach associated with this operative procedure. We have limited the use of the Watkins-Wertheim operation to those cases particularly with marked cystocele and with good fixation of the cervix at a fairly high level. It is particularly applicable in older women with marked cystoceles and good support of the cervix, particularly to fat women with these conditions, and to poor risks, avoiding as it does the necessity of an intra-abdominal procedure.

### TECHNIC

With the properly selected case, the patient is placed in the lithotomy position. The cervix is grasped and pushed well downward and backward so that the anterior vaginal wall is on the stretch. An incision through the vaginal mucosa with a sharp knife is then made just below the urethra to just proximal to the point where the cervix leaves the anterior vaginal wall. This is deepened until the wall of the bladder is seen beneath the vaginal mucosa and separated by blunt dissection with scissors on either side. This is picked up, as shown in Figure 253, *a*, with Ochsner clamps, scissors are inserted upward and downward toward the urethra and the cervix until the bladder is freely separated (Fig. 253, *b*). With the vaginal mucosa held back by the Ochsner clamps and with a sharp knife, the bladder is separated laterally in the sulcus which is present between the vaginal mucosa and the bladder musculature until a good line of cleavage is established. With gauze on the finger this is then wiped back laterally and upward from the anterior wall of the cervix (Fig. 253, *c*).

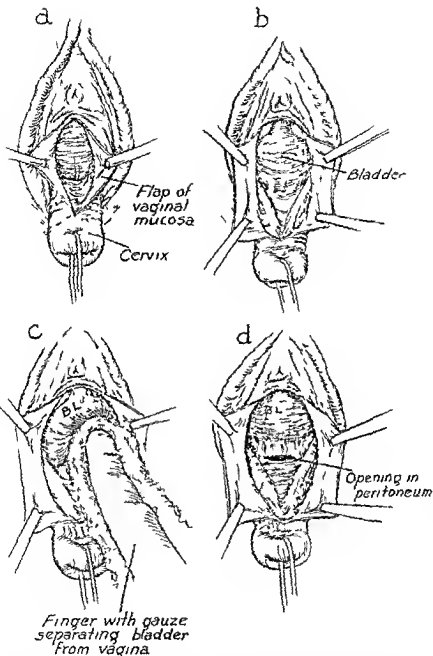


Fig 253—It is important to state that the posterior portion of the vagina is purposely omitted in these illustrations. This gives the misleading impression in these illustrations with the long cervix that a prolapse is present. This method of illustrating is employed merely to make the steps clearer. *a*, In this illustration the cervix has been pulled well down the incision of the vaginal mucosa has been made and separated laterally. *b*, The extent of the separation up to the

It is of great importance in the Watkins-Wertheim operation that the bladder be freed laterally as completely as possible. It should be so freed that it can be wiped up into a central position as a completely spherical structure (Fig 253, *c*). If the lateral extensions of the bladder over the front wall of the uterus are not freed and the fundus of the uterus is then inserted beneath the laterally unfreed bladder, there will be lateral sulci left in the bladder in which will occur stasis, on which will occur traction with bladder distention, and as a result of which there will be bladder discomfort. In the properly executed Watkins-Wertheim operation, the entire posterior wall of the bladder will be so mobilized that it can be pushed up into the pelvic cavity as a spherical structure (Fig 253, *d*).

One of the difficulties everyone who has not had a large experience with this operation will encounter is to determine when the bladder has been so wiped up that the peritoneal cavity is in sight. As the bladder is wiped freely upward over the front wall of the uterus, two lateral bands will be seen coming down to either side of the cervix which are expansions of the broad ligaments appearing as traction on the bladder upward and the cervix downward puts them on the stretch (Fig 253, *d*). Between the two will be found the fossa represented by the anterior wall of the uterus and the posterior wall of the bladder covered over by the free peritoneum now exposed. This can often be demonstrated by rubbing the two surfaces together on the front wall of the uterus and demonstrating the smoothly slipping, glistening surfaces of the peritoneal cavity. If the bladder is freely wiped up, one will be able to pass two fingers along the anterior surface of the uterus and feel the free peritoneum on his fingers above. With a ribbon retractor under the bladder lifted up, this fold of peritoneum can be visualized under good light and, with the cervix well pulled down to bring it into view, it can be incised as the peritoneal cavity is incised and opened in an abdominal incision (Fig 253, *d*).

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urethra is shown and underneath the upper edge may be seen the shadow of the urethra as it has been worked out laterally *c*, The bladder has been pushed well up in the midline and detached laterally. Note the sulci on either side from which one can fail to detach the bladder, thus producing gutters on either side of the remaining bladder if the fundus is inserted underneath it without this separation. Note the method of gently wiping the bladder up with a piece of gauze on the finger and with the lateral vaginal flaps held outward on the stretch *d*, In this illustration the bladder has been completely freed from its lateral attachments and from the anterior wall of the uterus and the peritoneal fold between the back of the bladder and the front of the fundus is now visible. The point of incision in it is illustrated by the dotted line. Note the bands of the broad ligaments running obliquely down to the cervix, between which is the fold of peritoneum to be opened.

As soon as the peritoneal cavity is incised the glistening surface on the interior wall of the uterus will immediately appear. This can be stretched with the fingers and with a double hook as shown in Figure 254 *a* the anterior wall of the uterus is grasped. This is pulled down and the peritoneal cavity held open with a retractor. The anterior wall of the uterus higher up is again grasped with another double hook and with double hooks literally walking up the front of the fundus the fundus of the uterus can then be tilted forward and pulled out through the opening in the peritoneal cavity between the uterus and bladder.

In the beginning of our experience we used to suture the layer of free peritoneum to the posterior wall of the uterus as it lay in its position beneath the fundus. This we have now given up for several years because of the advantage of having this opening through which any accumulation of blood serum or hematoma can escape into the peritoneal cavity and thus prevent the accumulation of hematomas beneath the bladder.

With the uterus now freely out of the peritoneal cavity and beneath the bladder the decision can be made as to whether or not an amputation of the cervix need be done. If it is determined that amputation of the cervix is to be done the entire uterus will now be visible (Fig 254 *b*) so that the vaginal mucosa can be cut off at a proper level. The cervix amputated the circular vessels running beside the lateral walls of the cervix tied and the vaginal mucosa stitched to the dilated cervical canal.

At this point one does well to review how freely the bladder has been mobilized laterally from the pubic arch and the urethra exposed. In the Watkins Wertheim operation the urethra should be well wiped out so that the junction between the urethra and the neck of the bladder can be visualized (Fig 254 *b*). It is necessary to do this (1) to get the bladder free and (2) to expose the pubic arch to which the fundus will be attached by chromic catgut stitches on either side of the urethra to fix it in position.

In inserting the two stitches in the fundus as shown in Figure 254 *c* one needs to be careful not to insert them too far out near the horns of the uterus where there is such a vascular area. Just inside the point where the fallopian tubes enter the horn of the uterus is a good place for the stitches to be inserted and good bites should be taken in the fundus of the uterus so that they will not pull out. Over the pubic arch the needle can be inserted deeply care being taken to expose the urethra to be certain that it is protected so that good fascial support is included in the needle. The lateral stitches as shown in

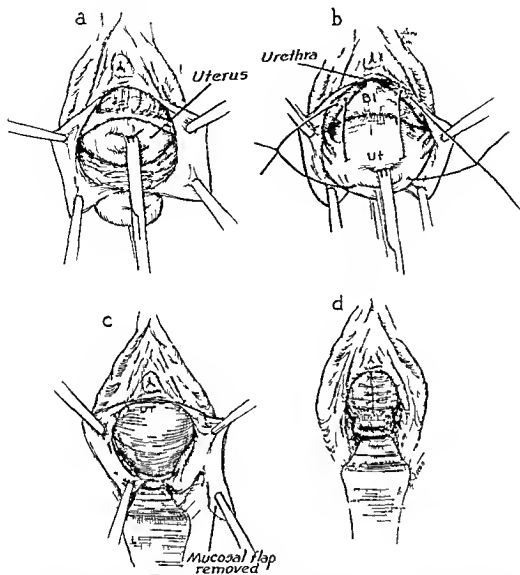


Fig 754—*a* In this illustration the fundus has been grasped beneath the bladder through the open peritoneum and pulled downward preparatory to fixing it in place *b*, Again it may be noted that the bladder has been carefully wiped off laterally beside the urethra so that the urethra is plainly visualized. The fixation suture has been inserted in the fascia beneath the pubis and through the fundus. *c* The uterus is shown fixed to the fascia beneath the pubis with the fundus of the uterus beneath the bladder held snugly up against the urethra. It is to be noted in this illustration that the extra flap of vaginal mucosa caused by the bulge of the anterior wall involved in the cystocele is being excised. Attention is again called to the necessity of being careful to avoid removing too much vaginal mucosa and again warning is given that it is better to leave too much vaginal mucosa than to take off too much thus narrowing the vaginal outlet. *d* The anterior vaginal mucosa has been closed with interrupted sutures and the cervix is now pointing backward. A high perineorrhaphy will now be done.



Figure 254, *b*, are now tied which fixes the uterus firmly against the pubis, against the urethra and beneath the bladder

At this point one does well to remember that too much vaginal mucosa must not be excised from the anterior vaginal wall flaps which have been taken off the cystocele. We have made the mistake of being too enthusiastic in cutting away vaginal mucosal flaps, particularly where the anterior wall has been bulged by cystocele, resulting in an inadequate amount of vaginal mucosa and an inadequate aperture as far as marital relations are concerned. It does no harm to leave too much vaginal mucosa since the support comes from the fundus of the uterus and not from the vaginal mucosa, and it is infinitely better than to excise too much of the flaps.

We have found it wise to use interrupted stitches in closing the anterior vaginal wall and not to place them too closely together so that, should oozing occur beneath the vaginal mucosa, hematoma will not take place but can drain in the spaces between the widely interrupted stitches (Fig. 254, *c* and *d*).

Following the completion of the Watkins-Wertheim interposition operation, a high perineorrhaphy is done and an indwelling catheter is left in place.

Immediately following the mobilization of the bladder, one should insert a catheter and drain off some urine to determine whether or not there is any blood in it, with the possibility that perforation of the bladder has occurred.

**Special Points**—There are a few points from this experience which will be of interest to anyone who is employing this operation. One is, what are the dangers of opening the bladder, and if it is opened can one repair it? We have rarely opened the bladder, but no one can have done the considerable number of these operations that we have without having done it. I personally have opened it three or four times with no disadvantage whatever. If one finds the opening, puts a purse string suture around it, carefully inverts the mucosa and supports it with an additional suture, puts in an indwelling catheter so that tension does not occur, no damage is done.

Another step which in my early experience was of advantage to me was to be able to determine the lowest extent of the bladder. In such cases the introduction of a uterine probe through the urethra, carrying it down to the lowest point of the cystocele, elevating the bladder anteriorly, will so pull the bladder away from the anterior wall of the cervix that one can easily determine the line of cleavage between the bladder and the uterus. After one has had a considerable experience with these cases, however, this step will be unnecessary and the bladder

can be separated from the anterior wall of the uterus with no great difficulty and with confidence

Because there is not infrequently a considerable amount of oozing from the anterior wall of the bladder, it will often be of advantage to introduce into the vagina for twenty four to forty-eight hours a small strip of iodoform gauze for its immediate pressure effect

The vesical fascia over the bladder, which is often loose and of very unsatisfactory thickness, can frequently be included in plication or by inversion stitches as an additional support to the bladder and to take the laxity on it brought about by the cystocele

**Important Factors in Obtaining Good Results**—The results of this operation have been extremely gratifying. All of the surgeons in the Clinic have employed it

If I were to review our experiences with it, again to enumerate the important factors in obtaining good results with it, I would say in conclusion (1) It must be applied to the proper type of case and that is the patient suffering primarily from cystocele, with a well suspended high cervix (2) To obtain good results from it, the bladder must be adequately and completely freed from the anterior surface of the uterus and from its lateral walls so that it can be pushed well up into the pelvic cavity (3) The uterus must be firmly and snugly anchored to the fascia beneath the pubis to fix it in this position (4) One must be careful not to excise too much of the anterior vaginal mucosa to avoid undue narrowing of the vaginal orifice (5) It is important that any disease of the cervix be cared for by amputation because of the difficulties of performing this operation later (6) The operation will need to be accompanied in most cases by a high perineorrhaphy in order to obtain the best results

## TECHNIC OF PERINEORRHAPHY

C C ENGLEMAN

An adequate pelvic floor is almost as important as is the entire set of fascial and ligamentous supports of uterus and bladder in maintaining pelvic organs in their proper position. With care, a damaged perineum can be built up into a strong and resilient supporting structure. Hence, we believe that a well executed perineorrhaphy is an essential part of any operation for prolapse, whether such procedure be done vaginally or abdominally, and is likewise an essential feature of every total hysterectomy, either abdominal or vaginal, in order to prevent the late complications of prolapse of the vaginal vault.

Although we have nothing new to offer in the technic of perineorrhaphy, it may be worth while to discuss some of its features in detail, for best results depend on attention to many details as well as to the underlying principles.

First of all, a thorough preoperative survey of the individual case must be made. The actual adequacy of the pelvic floor can be gauged only by examining the patient, always in the dorsal position and often in the standing position, while she is straining or bearing down. Evidence of cul de sac hernia should be looked for. It is often revealing to examine the patient several different times, one will sometimes find great variation in the degree of relaxation present. This fact, to which comparatively little attention has been paid, is really not surprising, general bodily vigor, muscle tone, and erectness of bearing change greatly from time to time, and the pelvic supports share in these changes. Obviously, the patient whose degree of perineal relaxation changes markedly from one examination to another is likely to need more attention directed to her general condition and less to the local one. Finally, it is evident that under anesthesia no true conception of the degree of relaxation or of the need for repair of the pelvic floor can be obtained.

### TECHNIC

The pelvic floor is opened by excising a strip of tissue (Fig. 255, a) just inside the vaginal opening, saving below the level of Bartholin's ducts, and reflecting a thin vaginal flap by blunt dissection as a rule, extending at least two thirds of the way up the posterior wall. The flap should be thin, the numerous veins being brushed down toward the rectum. If a cul-de sac hernia is suspected it is of prime importance

to carry the flap high, and then, wearing an extra glove, insert a finger in the rectum to put the rectocele under tension, and determine whether there is a cul-de-sac coming down from the pouch of Douglas.

If there is any degree of rectocele it is dealt with by a fine continuous suture to infold the rectovaginal fascia (Fig. 255, *b*), starting

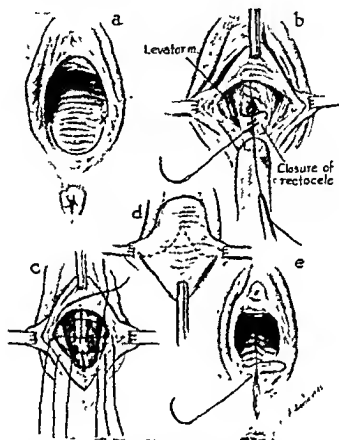


Fig. 255.—*a*, Line of opening into the pelvic floor, usually carried out by applying double hooks at either end of the proposed incision, separating them under heavy tension and excising a narrow strip of tissue. *b*, The rectocele is infolded by a continuous suture which catches the thin rectovaginal fascia. *c*, The levators are shown already united by a row of mattress sutures which have been tied. The interrupted sutures which build up the perineal body have been introduced but are not yet tied. *d*, Dotted line indicates extent of mucosa excised in an average case. *e*, Final suture line in the usual case converts the incision to a vertical closure.

just above the anus, going up to the top, and then returning to tie the knot at the starting point. The levators are then approximated (Fig. 255, *c*), usually with interrupted figure eight sutures. It is well to engage the loose tissue at the base of the flap with the highest stitch. Individual ligation of bleeding points usually is not necessary except for an occasional artery. The superficial tissues are then united by in-

interrupted sutures to reconstruct a perineal body of some thickness (Fig 255, c) A triangle of mucosa is excised (Fig 255, d) and suturing completed with a continuous stitch (Fig 255, e) coming down from the apex, at the highest point, the mucosa should be stitched to the fascia The closure must not be too snug, two fingers should be admitted easily Dyspareunia is likely to result from too narrow an introitus This is caused more often by tight suturing of mucosa than by building up the perineal body itself, and may often be obviated by excising only a small triangle of mucosa, or by the use of a suture line which is partly or even entirely horizontal rather than vertical Often an inverted "T" closure is used Subcuticular sutures may be used in the skin

A more satisfactory result will be gained by using numerous sutures of fine chromic, 0 or 00, than by using heavy strands tightly tied The aim of the repair is to build up a comfortable, pliable support rather than a thick and unyielding scar A vaginal pack is inserted snugly for hemostasis and removed the following day

#### RECTOVAGINAL FISTULA

Rectovaginal fistulas fortunately are becoming rare This condition calls for one additional step in the usual perineorrhaphy After the vaginal flap has been raised, the opening in the rectum, if low, is

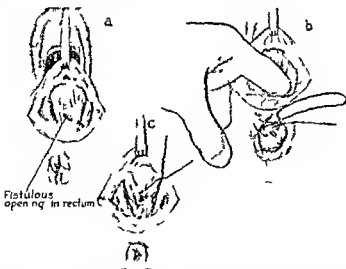


Fig 256—*a*, Fistulous opening in the rectum after elevation of mucosal flap *b*, Rectal wall everted through anal opening with the finger and fistulous opening closed with silk suture This suture will ultimately slough out *c*, Purse string suture of fine chromic catgut to reinforce closure of fistula This suture is introduced from the vaginal side of the bowel wall

closed by invaginating the bowel wall out through the anus with the finger (Fig. 256, *b*), and placing a fine, nonabsorbable suture from the rectal side. Then, from the vaginal side, an inverting mattress or purse-string suture further reinforces it (Fig. 256, *c*). The remainder of the repair is done in the usual way.

#### COMPLETE LACERATION OF THE SPHINCTER ANI

This condition may be managed by a slight modification of the usual perineal repair. The additional steps required are first, patient stretching out of the torn sphincter muscle with the finger tips before making the mucosal incision (Fig. 257, *b*); second, outlining the mu-

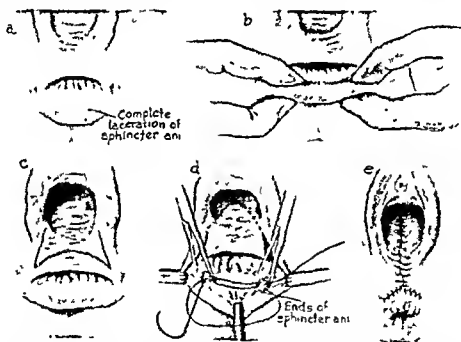


Fig. 257.—*a*, Dimples indicate site of ends of sphincter muscle *b*, An essential maneuver the sphincter muscle is stretched out by patient manipulation with thumb and finger so that it will regain its original length and can be repaired without being too tight. *c*, Line of incision inside the introitus so that flap may be turned down toward the anal opening. The vaginal flap above is elevated in the usual manner. *d*, The mucosal flap has been turned down and is being retracted laterally. The ends of the sphincter have been grasped with forceps and fine chromic sutures placed. Dotted line indicates the extent of mucosa excised in the usual perineorrhaphy. *e*, The perineorrhaphy has been completed.

cosal flap well inside the introitus (Fig. 257, *c*) and turning it down just enough to uncover the sphincter ends (Fig. 257, *d*) which are then picked up with forceps and sutured with fine chromic catgut.

The usual perineal repair is then carried out. The final suture line in perineal skin comes down above the anus as an inverted "Y" (Fig. 257, *e*).

## POSTOPERATIVE RESULTS FOLLOWING PRESACRAL NEURECTOMY

SAMUEL F. MARSHALL AND R. J. KENNEDY

RESECTION of the superior hypogastric nerve (presacral neurectomy) is well recognized as a sound surgical approach to the problem of severe dysmenorrhea in selected cases in which the symptoms do not yield to ordinary conservative measures. The history of presacral neurectomy has been related in detail in many communications on this subject and it adds little to the discussion to reiterate these well known historical facts. It is sufficient to state that Cotte first performed the operation known as presacral neurectomy and reported his case in 1925 in which he stated that there was immediate complete relief from symptoms of painful menstruation by this procedure. Since that time infrequent reports have appeared in the literature until somewhat recently when there have been more extensive reports on the final results following ablation of the sympathetic nerve. Many of these reports are based on relatively large series of cases.

The results of presacral neurectomy have been so uniformly good that there has been an ill advised tendency to employ this operative procedure in all types of dysmenorrhea. This is to be expected in view of the fact that the operation can be carried out with so little risk and according to most reports with no mortality whatever. The operation is regarded as a simple and rather easily performed surgical procedure. Its success depends very properly upon attention to many details of the operation especially the need for very careful selection of the patients upon whom the operation is contemplated and also the need for painstaking and accurate technical approach to the problem of actual resection of the superior hypogastric nerve. Although the procedure may be relatively simple in the hands of most surgeons it should be emphasized that the operation does involve the potential risk of any laparotomy and carries with it a certain amount of post operative distress and of course the factor of considerable economic loss to the patient. Presacral neurectomy therefore should not be advised without very careful physical examination and very careful evaluation of all the factors that may influence the occurrence of pelvic pain with menstruation. Phaneuf recently has given an excellent resume of the surgical treatment of dysmenorrhea and very clearly indicates the approach to this common problem. He rightly warns against the

tendency to employ presacral neurectomy in all cases of painful menstruation

Marshall and Poppen, in 1937, reported ten cases from this Clinic which represented the patients upon whom presacral nerve resection was done during the years 1935 and 1936. All of these patients were relieved of menstrual pain. In 1941, Colcock, from the Clinic, reported a series of thirty-five patients upon whom presacral neurectomy had been done for primary dysmenorrhea, and stated that 80 per cent obtained complete relief from their pain, 17 per cent had partial relief and one patient had no relief of her symptoms. The results given in the follow-up by Colcock very closely parallel those reported in the literature by other writers. Meigs, in 1939, reported a series of twenty patients who had had presacral neurectomy without any other type of pelvic surgery. Fifteen of his cases, or 75 per cent, had complete relief of their symptoms, three cases were complete failures, and two patients, or 10 per cent, had partially successful relief of their distress. However, it is well to remember that Meigs' report is based on a series of cases in which no other pelvic operation was done. Presacral neurectomy only was done in his series in order to evaluate more thoroughly the results of this procedure alone. As he pointed out, it is obvious that the correction of all pelvic disease yields better results than presacral neurectomy alone. In all probability the results in his group of cases would have been much better than the 75 per cent reported to have had complete relief if all pelvic disease had been eliminated.

Rutherford, in 1942, reported on a series of twenty three cases. There was a two year follow up after operation. He stated that thirteen patients had complete relief of all symptoms and that there was 75 per cent relief in six cases and 50 per cent relief in four cases, an over all percentage of 85 with complete or partial relief of pain following this procedure. Pemberton also reported his results in 1935 as 80 per cent complete relief in fifteen cases.

Since 1938, 219 patients at the Lahey Clinic have had presacral neurectomy performed for relief of painful menstruation. However no attempt has been made in this report to review the entire group of 219 cases. We have taken a representative cross section of this entire group of 219 patients and this review is based on the follow up reports obtained in 100 consecutive cases of presacral neurectomy done since 1938. In all of these cases, a sufficient period of time has elapsed following operation to establish the fact that the favorable results were not transient and that definite benefit has resulted from this operation. In eighty presacral neurectomy was done for primary or func-



tional dysmenorrhea, and in twenty for secondary or acquired dysmenorrhea.

The term *primary dysmenorrhea* is commonly employed to refer to the type of painful menstruation in which no gross pelvic disease or abnormality can be found upon examination. It occurs most commonly in young women in whom pelvic examination seldom discloses any abnormality, with the possible exception of moderately underdeveloped uterus which may be slightly anteverted. There is usually a history of painful menstruation from the onset of catamenia and very frequently the individual gives a history of pain which is increasing in severity and which recurs with every period.

*Secondary dysmenorrhea* refers to the symptoms occurring in a patient with demonstrable pathologic conditions in the pelvis, such as endometriosis, salpingitis, ovarian tumor, fibromyoma and various types of malposition of the uterus. Pelvic examination will reveal organic disease of the pelvic organs which might presumably be responsible for pelvic pain. Pathologic conditions in organs adjacent to the pelvic organs may well be a source of pelvic distress at menstruation.

#### PRESACRAL NEURECTOMY FOR PRIMARY DYSMENORRHEA

When patients are admitted to the Clinic with a history of dysmenorrhea with no evidence of pelvic disease, it is our practice to refer them to the medical department for conservative treatment before considering the possibility of presacral neurectomy. All patients upon whom the diagnosis of primary dysmenorrhea is made are treated with conservative measures, such as psychotherapy, attention to ordinary hygienic conditions, and various antispasmodic drugs, many new types of which have recently been placed on the market. Atropine, benzdrine sulfate and hormone therapy may be tried before operation. Many of these individuals will respond quite satisfactorily and operation will not be necessary. Others who are emotionally unstable may greatly magnify their complaints. Very often relief of the strain of bad home conditions and other situations which may add to the nervous tension frequently will alleviate their distress without any other treatment being necessary. It is important to avoid operation in this type of individual and it is in this neurotic type that pain is most likely to recur after operation and failure result. It cannot be too strongly emphasized that all types of conservative measures which seem indicated should be given a thorough trial before advocating operation.

All patients at the beginning of medical treatment and before coming to surgery are given a copy of the following brief resume, outlined by Dr. Frank Allan:

### Dysmenorrhea

Dysmenorrhea or pain at the menstrual period is suffered by one of every three or four normal young women.

When dysmenorrhea begins before the age of twenty, it is rarely caused by any abnormality of the pelvic organs. The importance of so-called displacement of the womb has been exaggerated. It should be known that one of every five or six women is born with the uterus lying backward (retroverted). Furthermore, dysmenorrhea with regular menstrual periods is almost never due to any important disorder of the endocrine glands.

The pains are caused by contractions of the muscle of the uterus. These contractions are not abnormal. In fact, they occur as a natural result of ovulation, the normal function of the ovaries preceding each menstrual period. They are absent when ovarian function fails.

The majority of women are not conscious of the contractions when they are mild. They are felt only when forcible. They may be stimulated by the accumulation of the menstrual fluid in the cavity of the uterus until the outlet of the uterus relaxes. Few women have dysmenorrhea after childbearing, perhaps because the outlet of the uterus, once it is widely stretched, permits freer passage of the menstrual fluid from the uterus.

Other symptoms which sometimes accompany menstrual pain, such as irritability, lethargy, headaches, nausea and vomiting, are probably the result of the nervous reaction to the pain.

Treatment may depend on the following factors:

1. Elimination of needless nervous tension from anxiety or other causes.
2. Simple medicines to relieve pain, such as aspirin or empirin compound, one or two tablets every four hours.
3. Sedative medicines to help relieve nervous tension.
4. Special medicines prescribed to suit the individual case.
5. *Surgical treatment in exceptional cases with special problems.*

If the pain can be relieved or satisfactorily controlled until the age of thirty, or until childbearing, there is likely to be little need for medical treatment later on. Special medical or surgical treatment may have to be considered under the following circumstances:

1. When the pain is so severe in spite of treatment that it causes disability each month.
2. When dysmenorrhea persists after the age of thirty.
3. When severe pains begin in adult life.

## PRESACRAL NEURECTOMY FOR SECONDARY DYSMENORRHEA

Presacral neurectomy has its value likewise in the treatment of painful menstruation occurring in the presence of organic pelvic disease. This is particularly true in the presence of endometriosis. It is well recognized that acquired or secondary dysmenorrhea beginning some years after the onset of catamenia may in many instances be caused by endometriosis. Young women with a history and pelvic findings suggesting endometriosis should be treated conservatively. Very frequently excision of one ovary and tube involved in the endometrial tumor combined with the correction of malpositions and presacral neurectomy will carry these individuals along for many years and completely relieve them of their pain. Hysterectomy with removal of both ovaries is a radical operation and may need to be done in the presence of extensive endometriosis but should ordinarily be deferred as long as possible. Later on with the development of endometriosis in the opposite ovary and tube or in the pelvic peritoneum or if severe pain recurs extensive surgery or deep therapy producing the menopause can then be carried out without regret.

For many years dysmenorrhea has been thought to be caused by retrodisplacement of the uterus and was commonly treated by dilatation and curettage and by some form of suspension. Unfortunately this is still done all too frequently. Should suspension be thought necessary at any time in the patient with severe dysmenorrhea presacral neurectomy should always be performed in addition to the correction of the displacement. In some cases it is of value to correct the cervical stenosis by thorough dilatation and not infrequently this relieves the symptoms but relief is likely to be transitory. Occasionally it is of value to employ these minor procedures before laparotomy and before excision of the superior hypogastric nerve. Twenty-seven patients in this group of 100 had previously had dilatation and curettage with transient or partial relief of their menstrual pain before submitting to presacral neurectomy.

As Phaneuf very properly pointed out pain occasioned by mechanical disturbance of the appendix such as that accompanying a retrocecal appendix or frequently from an appendix which has adhered to the pelvic organs may be increased at the time of menstruation. It is wise therefore, when presacral neurectomy is carried out that the appendix if still present be removed. It is our practice in all of these cases to remove the appendix and in the 100 cases reviewed fifty-eight had routine appendectomy done at the time of the neurectomy.

Sixteen patients in this series of 100 had had previous pelvic operations at which time some type of suspension or release of adhesions

had been carried out, without relief of symptoms in any of these cases. All sixteen patients had to have reoperation with presacral neurectomy, which could readily have been done at the first laparotomy, and thus they could have avoided a second operation.

White states that the superior hypogastric nerve or plexus is a sympathetic plexus and that the preganglionic fibers come from the lower thoracic and upper lumbar levels of the intermediolateral column. The postganglionic neurones originate in the sympathetic trunks as well as in the pre-aortic ganglia, to form a plexus descending along the abdominal aorta. At the level of the inferior mesenteric artery there are two small ganglia and from these the plexus descends to innervate the sigmoid and rectum. The remainder of the descending sympathetic fibers form the superior hypogastric plexus at the bifurcation of the aorta. This plexus then divides at the level of the bifurcation of the two common iliac arteries to form the two hypogastric nerves. These extend to the hollow of the sacrum to join the inferior hypogastric plexus. This sympathetic plexus then lies in a triangle bounded by the two common iliac arteries and originates at the bifurcation of the aorta. Both Meigs and White emphasized the fact that branches of nerves from the fourth lumbar ganglia join the plexus from under the common iliac artery and it is important to remove these branches in a clean dissection and removal of this sympathetic nerve.

#### THE OPERATION

The actual technique for the removal of the sympathetic plexus which forms the presacral nerve is not difficult if these anatomical facts are remembered and great care is taken to maintain a bloodless field during the dissection. Furthermore, it can be done in a relatively short time so that it may supplement any other gynecologic procedures that may seem indicated at the time of laparotomy or during any surgical procedure that may be necessary to remove any disease arising in the pelvic organs or in the rectosigmoid. Lahey and Cattell of this Clinic have long advocated combining presacral neurectomy with Miles resection of the rectum in the presence of extensive carcinoma of the rectum.

The operation is approached through a midline suprapubic incision. It extends from the umbilicus to the symphysis. After the peritoneal cavity has been opened (Fig. 258) a thorough abdominal exploration is made. The patient may then be placed in Trendelenburg position and the abdominal cavity walled off with moist saline packs. The sigmoid colon very frequently will lie near the midline and will obscure the operative field; it must be retracted laterally in order to approach

the field of operation. The posterior parietal peritoneum is grasped by forceps at the level of the fifth lumbar vertebra at the bifurcation of the abdominal aorta, and incised. Upon incision, it may be noted that the retroperitoneal areolar tissue immediately fills with air, and a potential space is easily demonstrable. The incision in the peritoneum is then extended for a distance of 10 to 12 cm. The peritoneum is re-

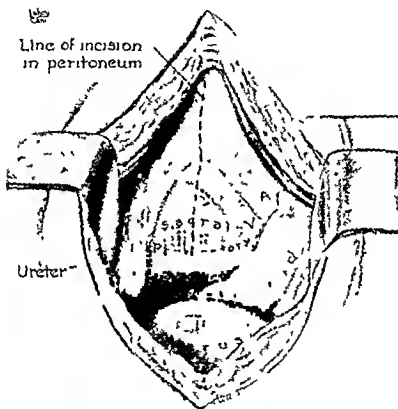


Fig. 258—Abdomen is opened through a midline suprapubic incision. The line of incision of the posterior parietal peritoneum is illustrated. Note the sigmoid retracted toward the left and also the position of the right ureter.

tracted by guide silk sutures on either border of the incision. The loose areolar tissue may then be dissected from the common iliac with scissors or with blunt dissection with gauze and forceps. The nerve is readily identified and all connective and areolar tissue is freed from the external iliac artery up to the bifurcation of the aorta (Fig. 259). The left common iliac vein is seen on the left side of the triangle, whereas the right iliac vein lies lateral to the right external iliac artery.

and does not come into the field. The ureter is readily seen and identified on the right side but is not usually seen on the left side. The tape is placed beneath the nerve and the areolar tissue and dissection carried up to the bifurcation of the aorta. All tissue is removed from the triangle cleanly as high as the bifurcation of the aorta where the nerve is divided and the proximal end of the nerve plexus is ligated to prevent

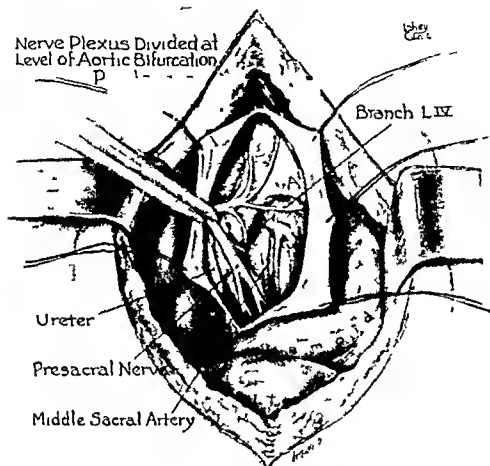


Fig. 259.—The posterior parietal peritoneum has been incised and the edges elevated with sutures of silk. The presacral nerve is elevated with a tape and removed with all areolar tissue from the bifurcation of the aorta down to the level of the bifurcation of the common iliacs.

any bleeding. The nerve plexus together with all areolar tissue is cleaned from above downward to the level of the bifurcation of the common iliacs. It is well to remember that the branches from the fourth lumbar ganglia come from under the iliac arteries and not over as do other fibers of the plexus, and these should be removed also. Care must be exercised to avoid injury to the left iliac vein which may

be easily traumatized. Any small bleeding veins can be tied and the field kept relatively bloodless. Occasionally it is necessary to tie the middle sacral artery, but usually injury to this can be avoided. The dissection is completed to the level of the bifurcation of the common iliac arteries. The nerve plexus is usually seen to form the two hypogastric nerves which by blunt dissection can easily be separated, clamped and ligated, removing the nerve tissue with the areolar tissue. The rent in the peritoneum is then closed with continuous running stitches of fine catgut.

Any corrective pelvic surgical procedure that is necessary can be done before or after presacral neurectomy. However, if large tumors are present in either ovary or if myomectomy is necessary, presacral neurectomy will be made much easier by the removal of these tumors, thus permitting a readier approach to the dissection of the nerve. It is essential also to correct any malposition of the uterus with any type of suspension the surgeon commonly employs. It is always wise in the presence of any pelvic abnormality in which severe dysmenorrhea is a prominent feature to perform the presacral neurectomy in addition to any surgical corrective measures necessary. The operation is not difficult although it may be painstaking. It can be added readily to any other pelvic operation and should not greatly prolong the time or the extent of the operation. One so frequently sees patients who have gone through extensive pelvic operations who continue to have severe menstrual pain in whom it is necessary to perform a second later laparotomy for a presacral neurectomy which could easily have been done at the first operation in order to relieve the patient completely of menstrual pain.

### RESULTS

In this series of 100 cases that have been reviewed in eighty cases as previously stated, presacral neurectomy was done for primary dysmenorrhea. No pelvic pathologic change other than slight displacement was found in any of these cases. In this group of eighty patients seventy-two report excellent results with complete relief of all menstrual discomfort. In two cases the results were fair. One patient was relieved of all menstrual discomfort but complained somewhat of the lack of propulsive power of the rectum since the operation. Another complained of occasional cramps and continued to have some backache at menstrual time but not sufficient to incapacitate her. In two cases the results should be classified as fair to good. One was relieved of her pain and cramps but had severe headache something she had never experienced before the pelvic operation. Another had slight

pains and cramps but was at least 75 per cent relieved. In three patients the results were listed as fair to poor. Menstrual cramps were relieved in one, but this patient had peculiar pressure discomfort in the region of the coccyx. This was noted only at the time of menstruation. Another reported only slight improvement, certainly not over 25 per cent relief of her distress. A third reported no relief of pain and must be listed as a failure. In one patient of the group of eighty no follow up was obtainable. In other words, 90 per cent had complete relief of all distress, 5 per cent had considerable relief if not complete, 3.8 per cent had partial relief and only one case, or 1.2 per cent, can be classified as failure.

In the group of secondary or acquired dysmenorrhea, comprising twenty cases, sixteen reported excellent results with complete relief of all menstrual discomfort. However in this group of twenty cases, other pelvic corrective procedures were done at the time of the presacral neurectomy. In two cases the results can be listed as fair to good, one patient having some menstrual cramp and backache, but relieved at least 70 per cent. One patient reported that cramps were relieved but she had some backache and was extremely nervous at the time of menstruation. One patient had no relief of her symptoms, she returned six months later with endometrial implants in the cul de sac, noted upon examination. Laparotomy confirmed the diagnosis and supra vaginal hysterectomy and ablation of the tubes and ovaries were necessary. In one case in this group follow up was not obtainable. In this group of twenty cases 80 per cent obtained complete or almost complete relief of their distress.

All patients were operated on under spinal anesthesia. In all cases careful dilatation and curettage were carried out, dilatation of the cervical canal is important to obtain correction of any cervical stenosis that might be present, and should always be done. No patients in this group were admitted for operation unless they had been carefully studied and the degree of pain evaluated as closely as possible. Conservative measures had been carried out under medical supervision in all cases and patients with low thresholds of pain or those emotionally unstable were subjected to conservative medical measures over a long period of time. The general hygiene was improved, antispasmodics and hormones were administered and psychotherapy applied. Only upon failure of these measures was presacral neurectomy advocated to relieve menstrual pain. In this group of 100 patients upon whom presacral neurectomy was done, the uterine malposition was corrected by some type of suspension in sixty nine cases.

There were no postoperative complications and no mortality follow



ing operation in this group. The average number of days spent in the hospital was fifteen and a half. The average age of the patients was twenty six and seven tenths years. The youngest patient subjected to presacral neurectomy for relief of menstrual pain was thirteen and the oldest in the group was thirty nine years of age.

No unfavorable sequelae such as interference with normal parturition, libido, menstruation or urination were reported in any of the cases studied. The group of patients seemed to be singularly free from unfavorable results following operation. Very little data could be obtained upon libido or problems associated with parturition in this group as most of these patients were unmarried and no evaluation of these questions could be made. However from data obtained from those married at the time of operation or subsequently married there seemed to be very little or no effect.

#### SUMMARY

Presacral neurectomy has been used in the treatment of intractable dysmenorrhea in 219 cases at the Lahey Clinic since 1938 over a period of six years. A brief report is given of the follow up results in 100 cases. Ninety per cent of the group of eighty patients with primary dysmenorrhea had complete relief of all symptoms associated with menstruation. Eight and eight tenths per cent can be listed as partially relieved and there was only one failure (1.2 per cent).

In the group of twenty cases of secondary or acquired dysmenorrhea 80 per cent are reported to have obtained complete relief of all symptoms, the remainder were partially relieved and again only one was a complete failure.

Presacral neurectomy is a valuable procedure but should be employed only in selected cases after a careful and complete study and only after the employment of conservative measures in patients with no organic pelvic disease. Careful selection of cases after a period of conservative medical measures will reduce greatly the number of cases in which presacral neurectomy will be required for the relief of pain and operation will result in a higher percentage of complete relief and consequently fewer failures.

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# ANESTHESIA FOR GYNECOLOGIC SURGERY

LEO V HANO

ANESTHESIA for gynecologic operations must insure the maximal degree of safety for the patient. The safety of the anesthesia is influenced by the agents and methods employed as well as by the skill of the individual administering it. The choice of agent and method for anesthesia in gynecologic operations is largely dependent on the extent of the contemplated procedure. Operations of short duration and requiring little or no surgical relaxation are usually classified as minor procedures. In this group are included pelvic examinations, dilatation and curettage, operations on the cervix, and modified perineal repairs. Operations of longer duration or requiring surgical relaxation may be classified as major procedures. In this group are included intra-abdominal pelvic operations, extensive perineal repairs, and combined perineal and intra-abdominal operations.

## ANESTHESIA FOR MINOR OPERATIONS

The methods of choice for minor procedures are intravenous, inhalation and caudal anesthesia. The inhalation anesthetic agent of choice is cyclopropane. The use of cautery or high frequency currents in these operations introduces the factor of explosive hazard. In the presence of this hazard an intravenous agent is employed, preferably pentothal sodium.

A technic for *intravenous anesthesia* has already been published.<sup>1</sup> A 2.5 per cent solution is employed. With the patient instructed to talk or count aloud, the solution is slowly injected (approximately 0.5 cc per second) until the patient stops counting. After a transient period of apnea there is usually an inspiratory sign followed by resumption of the regular respiratory excursions. When the patient requires less than 0.5 gm for induction (cessation of counting), 0.1 gm more should suffice for surgical anesthesia. If the patient requires more than 0.5 gm for induction, 0.2 gm will usually suffice to obtain adequate anesthesia. Fractional doses of 0.05 to 0.2 gm are added as the patient gives evidence of recovery or awakening. For patients requiring large quantities of the intravenous agent when used alone, the addition of 60 to 70 per cent of nitrous oxide with 40 to 30 per cent of oxygen by inhalation will give and maintain excellent anesthesia with greatly reduced quantities of the intravenous agent. This will not only shorten

the recovery period but also reduce the dangers of pulmonary complications from prolonged periods of respiratory depression.

#### ANESTHESIA FOR MAJOR OPERATIONS

The methods of anesthesia for major procedures may be classified under two main groups, inhalation anesthesia and spinal anesthesia. The inhalation anesthesia employed for these operations is closed system carbon dioxide absorption with cyclopropane-ether, either with or without endotracheal intubation. The customary agents employed for spinal anesthesia at the Lahey Clinic are pontocaine and nupercaine. Saklad, reviewing the work by Nowak, reported corrected toxicity ratios for these agents in spinal anesthesia compared to procaine or novocaine as metycaine 1.36:1; pontocaine 0.58:1; and nupercaine 0.71:1. Spinal anesthesia, with light supplementary intravenous or inhalation anesthesia, approaches more nearly the optimal anesthesia for major gynecologic operations than does any other method. This combination, when properly handled, provides unvarying relaxation of the abdominal muscles, which, together with the contraction of the intestines and the quiet regular action of the diaphragm, produces most favorable operating conditions.

#### SPINAL ANESTHESIA TECHNICS

The agent and method to be employed for spinal anesthesia depend on the contemplated operation. For operations probably lasting less than one and one half hours and requiring little or no Trendelenburg position, pontocaine with dextrose solution by the Lahey Clinic (Sise) technic<sup>2</sup> has proved satisfactory. Combined perineal and intra-abdominal operations frequently exceed one and one half hours. These operations often are performed in moderate to steep Trendelenburg position. Pontocaine-dextrose solution usually does not last longer than one and a half to two hours. Also this solution (Sise) is heavier than spinal fluid. In Trendelenburg position there is danger of cephalad progression of anesthesia with resultant dangers of respiratory depression. Therefore, in such operations nupercaine, 1 to 1500 dilution, using a modification of the Howard Jones technic<sup>3</sup> is employed. This agent produces excellent abdominal anesthesia for two to two and a half hours' duration. This solution of nupercaine is lighter than spinal fluid; thus when Trendelenburg position is desired, the direction of progression of the anesthetic solution will be caudally. In operations of a contemplated duration of over one and one half hours in which little or no Trendelenburg position is planned, continuous spinal anesthesia may be employed. Our agent of choice for continuous spinal

anesthesia is pontocaine dextrose.<sup>2</sup> In nearly all spinal anesthetics, 50 mg of ephedrine sulfate is given intramuscularly prior to introduction of the spinal anesthetic agent. This acts as a prophylactic agent against the fall in blood pressure that might occur following injection of a spinal anesthetic solution.

**Pontocaine Dextrose Technic**—The anesthetic solution for this technic is prepared by adding to the estimated dose of 1 per cent pontocaine in normal saline solution one and one half times its volume of 10 per cent dextrose solution. The average doses as employed at the Clinic are listed in Table 1.

For induction, the patient is placed in 5 degree Trendelenburg lateral decubitus position and the total quantity of solution determined upon is injected into the third lumbar interspace at the rate of 0.25 cc

TABLE 1—APPROXIMATE DOSES OF PONTOCAINE FOR ADULTS

	Mg *	Mg †	Mg ‡
Perineum			
External genitalia or bladder }	9	12	14
Legs to groin or pelvis (intravaginal)	10	13	15
Lower abdomen	12	16	18
Upper abdomen	13	17	20

\* For older weaker smaller individuals

† For the average patient with fairly good vigor

‡ For younger more vigorous larger individuals or for especially long an-  
esthesia

per second, with no barbotage being employed. This mixture is considerably heavier than spinal fluid. The height of anesthesia is obtained essentially by gravity. The patient remains in this 5 degree Trendelenburg position until the level of anesthesia is found to be within two thoracic nerve segments of the height desired or for not more than a four minute interval. Marked increased intra abdominal tension such as occurs in pregnancy, in cases of very large ovarian cysts or fibroids, as well as in early lithotomy position, exerts an influence on the height of anesthesia. Dangerous and undesirable heights of anesthesia will result in these conditions unless extreme care is taken to keep the level of anesthesia on initial tests low. In such instances it is wiser not to employ the Trendelenburg position on initial injection of pontocaine-dextrose solution.

During the induction period with pontocaine dextrose solution, the head is flexed so as to increase the thoracic curve. In this position the most dependent area of the spine is in the region of the third to the fifth thoracic segment. This tends to prevent undesirable heights of

**anesthesia** The thyroid lift bar or some similar attachment or a sand-bag 3 or 4 inches in thickness in the absence of any special apparatus placed under the occiput, is found to be an ideal lift for flexing the head of the patient. When the desired height is obtained, the patient is returned to a level or horizontal position for a period of fifteen to twenty minutes. Slight Trendelenburg position may then be employed with caution if desired.

**Nupercaine Technique.**—As already stated, the solution employed is nupercaine 1 to 1,000 dilution in 0.5 per cent saline solution. The specific gravity of this solution is 1.00345. The solution is supplied by the manufacturer in 20 cc. ampules and is acid in reaction. As this drug precipitates in the presence of an alkaline medium, the syringe and needle should be thoroughly acidulated to remove any traces of alkali. This can be accomplished most easily by rinsing with 1 cc. of the nupercaine solution. Prior to rinsing, the 20 cc. syringe and ampule are warmed to at least body temperature. This probably speeds up induction so that the desired height of anesthesia is frequently obtained in three to twelve minutes instead of the usual seven to fifteen minutes. The sex and height of the patient determine the dose. As we believe the volume of the nupercaine solution is the important factor in obtaining anesthesia, both in level and duration, the following doses are employed: for a 5 foot woman, 16 cc., for a 5 foot man, 17 cc., for every 3 inches over 5 feet, 1 cc. of nupercaine solution is added, the total dose never exceeds 20 cc. Occasionally the risk of the patient influences our estimations of dosage, but not more than 1 cc. of solution.

Lumbar puncture is made in the third lumbar interspace, with the patient lying on the side in the horizontal position. We prefer to withdraw and discard approximately 5 cc. of spinal fluid. We believe this tends to lessen the possibility of sudden severe headache that might occur during the injection of this volume of solution. After discarding the spinal fluid, the previously estimated and prepared warm anesthetic solution is injected at the rate of approximately 0.5 cc. per second. Immediately following this injection the patient is turned to a prone position, without pillows under the head.

When height of anesthesia is desired, in order to make the light nupercaine solution run to the desired position in the spinal column we raise the upper thoracic level by means of a lift bar under the upper portion of the patient's sternum until the spine slants upward at approximately 15 degrees to the horizontal. Special care is used that the head of the patient is lower than this uppermost thoracic area. In many instances the patient is placed in a perfectly prone horizontal position if height of anesthesia is not deemed necessary. Two minutes after in

jection of the anesthetic solution its upward progress is tested frequently by pinching with a clamp adequate to elicit definite pain response. The usual lapse of time to obtain the desired level of anesthesia ranges from three to twelve minutes.

When anesthesia has reached the desired level, first the table is placed in a 10 degree Trendelenburg position and *then* any apparatus under the patient's sternum is completely lowered. This prevents further cephalad extension of the anesthesia. Only after Trendelenburg position has been assumed should the patient be turned supine. As always with this technic, care should be taken to have the head of the patient in the most dependent position. Occasionally we find that the level of anesthesia is obtained more rapidly than is customary and that in two to four minutes after injection it has extended higher than is desired. It is for these cases that one must be on the alert by early and frequent testing. When such an anesthesia is encountered, the patient should immediately be placed in 10 degree Trendelenburg position and any lift bar under the sternum completely lowered, leaving her in the same prone position for approximately seven or eight minutes. This time interval in the prone Trendelenburg position not only insures complete bathing of the sensory or posterior nerve roots by the hypobaric or light solution but also causes the solution to retreat somewhat from its extended cephalad position so that when the patient is turned supine, the anterior or motor roots will not be affected as far cephalad as the posterior sensory roots.

**Supplementary Anesthesia**—Supplementary anesthesia is occasionally resorted to when the patient is uncomfortable as a result of traction reflexes. This supplementary anesthesia may be administered by inhalation or by intravenous injection. This combination of spinal and supplemental anesthesia with adequate oxygenation seems to us the best anesthesia for the following reasons: operating conditions are unsurpassed, and the patient is quiet and comfortable.

### CONCLUSION

For operations deemed minor procedures, inhalation, in the form of cyclopropane anesthesia, or intravenous anesthesia, sodium pentothal, is preferred. For major operations our experience has demonstrated that optimal operating conditions plus increased safety factors for the patient are obtained under spinal anesthesia, with or without supplementary anesthesia.

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# THE PRESENT STATUS OF DIAGNOSIS AND TREATMENT OF UTERINE CARCINOMA

HUGH F HARE

RECENT improvements in the diagnostic criteria of uterine malignancies have paved the way for earlier diagnosis of this very important disease, and will in the future increase the percentage of cures and five year survivals, whether the lesion be treated surgically or by radiation I wish to review our present diagnostic and therapeutic measures since most of the diagnostic measures may be successfully carried out in the examining room and laboratory

The method of Papanicolaou and Traut for the diagnosis of uterine cancer by *vaginal smear* is undoubtedly the most valuable diagnostic aid which has been brought to light since the advent of the biopsy True, this test is not infallible any more than any other laboratory test It requires the opinion of an individual trained in recognition of this particular type of disease, and thorough correlation of the findings with the clinical history This procedure has thus far not withstood the test of time and undoubtedly some investigators have already discarded it With any new method there are trials In our own experience we have made several of these trials only to pass on to others, but on the whole this test is successful The experience with this type of examination has revealed the importance not only of having trained personnel for the diagnosis of the smear after it has been taken, but also of the preparation of the smear for interpretation This procedure is adequately outlined in the monograph by Papanicolaou and Traut We have followed their outline closely, using a suction apparatus attached to a 10 cc Luer Lok syringe (Fig 260), the same type that is used when carrying out an air insufflation and uterotubography The apparatus permits removal of material from the walls of the vagina by suction, from which one smear may be made Material may be withdrawn from the cervical canal for a second smear

The vaginal smear method should be used only as an adjunct in diagnosis Regardless of the laboratory test, the history and the physical examination are the important diagnostic criteria The laboratory procedure should be used only to confirm the history and examination In the past, although the history has been available and many times ulcerations of the cervix or enlargement of the uterus were present, hospitalization was necessary to carry out the diagnostic procedures

The vaginal smear method allows a study of the cells present in the vagina and cervical canal which obviates, many times, the necessity of a hospital stay so that a diagnosis can be made.

Before the advent of the vaginal smear method of diagnosis, it was our practice to perform a *biopsy of the cervix* whenever suspicious lesions were demonstrated on vaginal examination. The specimen was taken at the time of the pelvic examination and did not in any case produce bleeding or infection. If representative specimens are taken of the area of ulceration, there is little likelihood of missing an early malignant tumor by this method. In order to take specimens of the cervix, a long-handled cutting biopsy forceps, with sharp, thin edges, is required, which permits grasping the tissue and cutting without

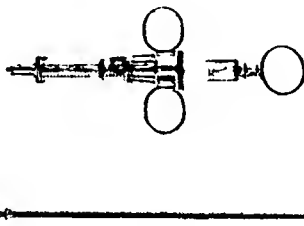


Fig. 260—Suction apparatus used for vaginal smear

pulling. The type of instrument shown in Figure 261 has been very successful in our hands. It permits removal of a large enough piece of tissue for successful microscopic study.

Thus it is seen by carrying out these simple office procedures, a complete history, physical examination, vaginal smear, and biopsy of the cervix when indicated, many diagnoses may be made and confirmed and the proper treatment planned before the patient enters the hospital. Using these available methods, earlier diagnoses of malignant disease of the uterus will be made more frequently and will give the cancer therapist an opportunity to cure more of these patients, whether the treatment be operation or radiation. It is our plan and has been for a number of years to remove surgically all grade I malignancies of the cervix and to treat the others by radiation. Unfortunately, the larger

proportions of these cases were grades II III or IV at the time the patients came for treatment so that only a few of them have had the advantage of a short convalescence which a surgical procedure offers. We believe that most patients with carcinoma of the corpus should be treated surgically unless there has been invasion and that this treatment should be followed by irradiation unless the malignant lesion is found to be in situ at the time of the histologic examination. Thus our treatment of this condition remains the same except that the trend is toward operation rather than toward irradiation because the lesions are diagnosed earlier by these procedures at a time when their removal is more favorable.

The surgical treatment of this condition requires panhysterectomy of the Wertheim type and is discussed by Dr. Lahey on page 505.

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Fig. 261—Biopsy forceps

Radiation treatment however has never been standardized which probably indicates that no successful method thus far has been devised and approved by all radiation therapists. Until such a method is developed there will probably be as many types of radiation treatment and as many variations of dosages as there are radiation therapists. It is only for the last few years that intensive roentgenologic therapy could be successfully applied. There has been much indecision with the advent of 200 000, 400 000 and 1 000 000 volt machines all appearing about the same time and all more or less shock proof for the first time. Then too about this time an accurate means was developed of measuring the dose of x rays and a study of the physics of irradiation especially depth dose was carefully undertaken. About the time the therapist made up his mind to proceed with one method something new came to light which appeared to be an improvement. Therefore

there has been constant change, all for the better to be sure, in our method of treatment so that we cannot properly say as yet that there is a standard procedure. All of this is mentioned to explain to the specialists and practitioners of medicine why there is so much variation of opinion amongst the radiologists and roentgenologists.

Again, only a short ten years ago, Coutard brought to this country a method of roentgenologic treatment which he considered better than all others. It was mainly the administration of intensive doses of x-rays, sometimes daily, sometimes twice daily, depending on the type of tumor present, and given until the tumor had been destroyed, using an apparatus of low milliamperage. His method soon swept the country and everyone placed a different interpretation on his plan of treatment, Coutard himself did not continue his plan of treatment once he came to this country.

Our plan of treatment for carcinoma of the cervix by *roentgen rays* has remained the same for the past ten years. We treat through four portals, centering the beam over the cervix and uterus, treating two portals anteriorly and two portals posteriorly. The factors used are 200 KVP, 50 cm distance, 15 cm round cone, 1 mm copper and 1 mm aluminum filtration. Using measurement in air, we give a total of 2000 r to each portal, giving 100 r per portal per day to deliver a total tumor dose of 3829 r. This method eventually brings the total air dosage to 8000 r, and a uniform dose to the tumor which, of course, is much smaller. The response of the tumor to this type of radiation has been satisfactory and the degree of skin reaction and soft tissue changes has been negligible. There have been no late changes in the skin. Inflammation in and around the tumor and secondary infection soon disappear with roentgen treatment, and usually bleeding stops within two weeks, provided the tumor is radiosensitive. Toward the end of the treatments some diarrhea usually develops as a result of bowel irritation, and often dysuria and frequency occur, which may be adequately controlled by small doses of paregoric or kaomagma.

After roentgen treatment has been completed, reexamination is carried out two or three weeks later. If the response has been satisfactory, and there is not too much radiation reaction, the patient is then ready for the first application of *radium*. This time interval is allowed in most cases because of the reaction in the bladder and rectum, caused by the irradiation. Following roentgen treatment, we give two applications of radium or radon within a two months' period, provided no complications set in. At each application, 3000 millicurie hours of radon are given. At the time of the first application, the radon is inserted into the cervix and uterus after any necessary dilatation,

giving a large dose in the cervical canal and a smaller dose in the corpus of the uterus. The tube is usually divided into two parts, using 150 mg of radon in the cervical end and 50 mg in the uterine end, thus giving a dose of a ratio of 3 to 1. The radon tube is inserted into the cervix, held in place by gauze pledgets which have been soaked in 50 per cent glucose solution and allowed to remain in place until a total dosage of 3000 millicurie hours has been attained. The radon is then withdrawn without much discomfort to the patient and without odoriferous discharge as the glucose destroys the growth of organisms so often found in this type of case. Two to three weeks later the lesion is treated directly with radium needles which are inserted into and around the lesion so that a uniform application of radium may be obtained. The needles are left in place until 3000 milligram hours have been given. The filtration of radium need not be brought up again for discussion, as it is well known that platinum filtration produces much less reaction in the adjacent tissues.

There have been some unfortunate complications following the use of radium. Very few have been noted when the plan described has been followed. In some instances in which the lesion involves the posterior lip of the cervix it is impossible not to damage the rectum and in a few cases rectovaginal fistulas have resulted not only from application of radium but also from extension of the malignant growth itself. Again when the superior lip is involved, the bladder wall may be invaded and a vesicovaginal fistula result. These lesions are always easily demonstrated. The lesion which we have been unsuccessful in demonstrating early has been involvement of the ureters following radiation. The frequent involvement of the ureters in cancer of the uterus has been well established. For this reason intravenous urograms, careful urinalysis and determinations of the nonprotein nitrogen content are made in each case before treatment is begun. This gives us a starting point and indicates the status at the beginning of treatment. In many cases, it has been difficult to determine whether the involvement of the ureters following radiation treatment was the result of irradiation or of malignant disease. In most instances, when enough time had elapsed, it was found that involvement of the ureters following treatment usually indicated that the tumor had progressed in this direction and that intensive radiation treatment had been only palliative.

Injuries to the bowel other than those to the adjacent rectum have been infrequent. In only one instance has there been radiation damage to small bowel which was adherent to the uterus. In this particular case there was diffuse involvement of the pelvis by the malignant process.

In considering radiation treatment it is advisable at this time to dis

cuss the value of cervical smears following irradiation. Dr. Shields Warren has noted that the cells cast off following even small doses of roentgen rays are similar to those seen in malignant disease, and therefore this is not a useful method for studying the results of radiation treatment. Only frequent histologic study of sections of the tumor can give us this information. It also makes us realize the importance of taking vaginal smears before any form of radiation treatment is begun.

The roentgenologic treatment following surgical removal of the corpus uteri is the same type as is given prior to radium treatment in cases of carcinoma of the cervix.

The results of treatment of malignant disease of the uterus indicate that the earlier treatment is given, whether it be surgical or radiologic, the better chance the patient has of surviving, and that most of us are basing our results on cases which are not favorable for treatment by any method. It is useless to judge the value of treatment in these hopeless cases, but analysis gives us the opportunity to determine the survival rate.

The patient who is properly treated will not have many complications as a result of operation or irradiation. It is my belief that intensive roentgen therapy should not be given in cases known to be hopeless from the start, but rather an attempt should be made at palliation and to control bleeding to carry these very needy patients through their terminal stages.

#### SUMMARY

The methods used at the Lahey Clinic for diagnosis and treatment of uterine cancer, the vaginal smear method of Papanicolaou and Traut, and biopsy of lesions of the cervix as an office procedure have been discussed.

We do not believe at the present time that we can depend entirely upon the smear method for diagnosis, but in many instances correlation of the smear, clinical history and physical findings will aid in arriving at an earlier diagnosis. Biopsy should be carried out routinely in all cases of cervical ulceration, with removal of enough tissue for careful histologic study.

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## ENTERO-UTERINE FISTULA CASE REPORT

RICHARD B. CATTELL AND EDGAR F. SEWALL, JR.

ENTERO-UTERINE fistula is rare. Danforth and Case reported fifty-eight cases in 1933. Three causes are mentioned by them: rupture of the uterus, peritonitis and malignancy. In rupture of the uterus, a portion of bowel may be caught in the area of rupture and as the uterus contracts down, the bowel is compressed in the defect, causing pressure necrosis, and a fistula between the uterus and bowel results. A few cases have been reported following both spontaneous and traumatic rupture. A communication between the bowel and uterus can be caused by an abdominal abscess. If the bowel and uterus are bound together by inflammation and an abscess forms, it can rupture in either direction. In malignant disease the same condition may be produced. The cancerous tissue of the uterus forms adhesions to the bowel and when ulceration and necrosis occur, a fistula often will result. The fistula can be formed in either the small or large bowel, and cases have been reported in which the stomach was involved.\* The small bowel and sigmoid are the most commonly involved. A combination of the latter in the same person has been reported by Le Jemtel.

The case to be reported occurred following a cesarean section. The etiology in this instance is infection and trauma.

### CASE REPORT

The patient, aged forty three years, had been well all her life until 1936 when she became pregnant for the first time. She had small pelvic measurements and after a trial of labor, she was subjected to a classical cesarean section. She did well for three days and then left sided pain and vomiting developed. Under supportive care she improved in a week. Shortly after the sutures were removed an abscess in the left side and a fecal fistula developed. The incision then opened, there were signs of intestinal obstruction, and pus mixed with feces drained from the abdomen and vagina. After a long and stormy course she recovered. One abdominal fistula remained. An attempt made to close this failed, but later the fistula closed spontaneously. She remained fairly well after that except for intermittent periods of nausea, vomiting and severe abdominal pain which required morphine. These attacks were relieved under expectant care, and fecal discharge from the vagina followed.

Physical examination revealed that the patient was thin. There was a 7 inch midline scar on the abdomen. No fistulas were present. On

pelvic examination the uterus was freely movable and not attached to the scar. There were no masses and no evidence of fistula. Rectal examination did not demonstrate any abnormality. Proctoscopic examination showed induration on the posterior rectal wall. A uterogram showed a sinus from the anterior wall of the uterus to the small bowel (Fig. 262), and operation was advised.

The findings at operation were as follows: (1) a loop of midileum was attached to the skin of the abdominal scar, (2) there was a fistula between the ileum 20 cm. from the ileocecal valve to the fundus of the uterus, (3) the uterus was slightly larger than normal and there was a



Fig. 262. Uterogram showing a sinus from the anterior wall of the uterus to the small bowel.

depressed scar on the fundus and (4) the ovaries were surrounded by adhesions. The sigmoid was firmly adherent to the skin of the scar. The adhesions were divided, and the uterus was freed from the small bowel, and revealing the site of the fistula. The ileum was separated and the defect closed transversely. The uterus was freed from the sigmoid and bilateral salpingo-oophorectomy and supravaginal hysterectomy were performed. The pathologist's report was: entero-uterine fistula, leiomyoma of the uterus, tubo-ovarian adhesions and healed appendicitis. Convalescence was uneventful except that on the fourth day there



was a rise in temperature to 101, it returned to normal in two days. The patient left the hospital on the fourteenth day.

#### COMMENT

As already stated, entero-uterine fistula is caused by either one or a combination of the following (1) rupture of the uterus, (2) peritonitis, and (3) malignant disease of the uterus or bowel. The case presented had two causes, rupture and peritonitis. In this case the small bowel became adherent to the uterine incision and later ruptured into the endometrial cavity, causing a fistula.

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## TRICHOMONAS VAGINALIS VAGINITIS

### Diagnosis Treatment, Causes of Failure in Treatment

CARL J. BOEHME

AMONG feminine patients there is probably no complaint that is as prevalent as vaginal leukorrhea. Careful history and pelvic examination of female patients will reveal many cases not mentioned because of modesty, or because leukorrhea was thought to be a natural condition no matter how irritating or distasteful. The more profuse the leukorrhea, the greater the probability that it is caused by the *Trichomonas vaginalis*. Since modern therapy of *Trichomonas* infections is specific and effective, such admonitions as "stay off your feet as much as possible," or "occasional cleansing douches" no longer suffice. The majority of patients are very willing to carry out treatment that will rid them of the disease.

#### DIAGNOSIS

**History.**—When a patient complains of a "discharge," it must be determined by questioning whether this is a feeling of moisture or actual staining of the underclothes. It should be distinguished from the normal discharge of mucus that occurs just before the menstrual period. In *Trichomonas vaginalis* vaginitis burning and itching of the vulva may be prominent symptoms. Urinary frequency with associated dysuria may be present. Usually the patient notices a malodorous yellowish discharge which in some cases will literally flow out of the vagina.

The disease, which may have been quiescent, frequently flares up after the first few days of marriage. The rapid appearance of profuse leukorrhea associated with burning and itching has often convinced the patient that she had contracted a venereal disease. Recently a distraught young woman in such circumstances started divorce proceedings against her husband who had gone overseas after two weeks of marriage. A diagnosis of gonorrhea had been made from the clinical history and appearance, but a smear had not been obtained. When we examined her, numerous trichomonads were found in the fresh smear, and repeated smears over a two month period failed to reveal gonorrhea. Subsequent check of the husband for specific infection was negative from both history and examination.

One symptom common in *Trichomonas* infection is that of a pinkish or bloody spotting. The multiple punctate lesions of the vaginal mucosa bleed easily. In young women whose complaint is that of a pinkish or brownish discharge a positive smear for *Trichomonas* will usually obviate the necessity of a diagnostic curettage. In the older age groups the possibility of malignant disease must be considered if though *Trichomonas* be found there is not a moderate or severe degree of vaginitis to account for the symptoms. It must be borne in mind that both malignancy and *Trichomonas* may be present. In certain cases the diagnostic curettage must be done before treatment of the *Trichomonas* infection is instituted.

**Examination**—The introitus may exhibit the milky or yellowish colored secretion. There may be evidence of irritation of the vulva and perineum. The vagina may be edematous and dark red in color. The vaginal wall and cervix may present punctate red spots. These will show up most typically on the cervix. In quiescent cases the vagina and vulva may appear normal. The secretion pooling in the lower blade of the speculum is often yellowish and foamy.

Microscopic examination of the fresh secretion must be made. A drop from the speculum mixed with a drop of saline or water and examined under the microscope will reveal the motile trichomonads. The organism itself is highly transparent and the movement of leukocytes adjacent to the trichomonad reveals its presence. By cutting down the light of the microscope the pear shaped protozoan with one or more of its active flagellae may be seen. The organism is often found in the microscopic sediment of freshly examined urine specimens. A cotton swab may be introduced into the vagina to obtain a specimen when the hymen is nearly intact.

Failure to find the *Trichomonas* on the first examination is a common experience. The patient may have had a douche in the twenty four hours before coming for examination. She should be instructed to return again after not having had a douche for several days or even a week. If symptoms persist we have learned to be persistent in checking the smear again and again. The organisms are usually found.

A careful inspection of the cervix and endocervix must always be made. A smear for gram stain should be taken from the cervix in every case. The Bartholin glands should be inspected for possible involvement. Although vaginal thrush is very uncommon it must be suspected when other tests are negative. The *Monilia albicans* can be identified in the dry smear after washing the slide with a few drops of tenth normal sodium hydroxide. The program for *Trichomonas* will cure the thrush infections.

## TREATMENT

Nearly everyone treating patients with Trichomonas infection has a "plan" of treatment with favorite trichomonocides and douches. Since many of the patients live a considerable distance away from the Clinic and cannot easily return for frequent check-up examinations or powder insufflations, our plan of treatment is carried out entirely by the patient. If there is an associated cervicitis or endocervicitis this is corrected by cautery before other treatment is started. If this is not done, the increased alkaline secretions from the infected cervix will interfere with the restoration of the normal vaginal acidity. The trichomonads will not live in the normal hydrogen ion concentration of the vagina of the young adult (3.8 to 4.4). This acidity is maintained by the conversion of the glycogen in the epithelium to lactic acid. This is done chiefly by the Doderlein's bacilli and is probably aided by vaginal enzymes. In the presence of mixed vaginal infections or infections in the cervix, during menstruation, and after the menopause alkalinity is approached. In this lowered hydrogen ion concentration the trichomonads live in abundance.

Therefore, the treatment of patients with Trichomonas infection must not only include a trichomonocide, but it must furnish sugars to be stored as glycogen in the vaginal epithelium and provide a favorable medium for regeneration of the Doderlein's bacilli which help maintain acidity. We prescribe floraquin tablets which contain diodoquin (5,7-diiodo-8-hydroxyquinoline) a protozoocide, boric acid, and lactose and dextrose. The program of treatment here described extends over a three month period. Printed instructions are given to each patient. These must be augmented by carefully explaining each detail of the treatment to the patient.

## Instructions to Patient†

1. At bedtime prepare a douche solution using 2 quarts of warm water into which is put 3 ounces of ordinary household vinegar. Lying in the bath tub, wash the vulva and anal area with soap and water. Follow this by the douche, using a large bulb syringe or a hanging bag. Insert the nozzle well into the vagina and hold the lips of the vagina together around the nozzle to distend the vagina with the solution. Release the pressure in the vagina and allow it to empty frequently. Conclude the douche by rinsing the vulva and anal area with the douche solution.

2. After the douche, moisten a floraquin tablet with water, insert it high into the vagina and leave it there.

3. Do this every night for six weeks and then every other night for the second six weeks.

4 During each day of the menstrual period take the douche in the morning and at bed time After the douche insert two of the tablets into the vagina

5 Do not take a douche for one week before you return for a check-up of the condition

Note The common name for this condition is Trichomonias It is *not* a venereal disease and is not contagious It probably comes from rectal contamination Cleansing the anal area after bowel movements should be done by wiping backward instead of forward Carrying out the treatment conscientiously in every detail is necessary for successful results

#### CAUSES OF FAILURE IN TREATMENT

When the three month check up is made, nine out of ten patients are free from the leukorrhea and the trichomonads cannot be found in the smear If the condition is unimproved, either the patients have not been impressed by the necessity of following the treatment carefully, or they have made errors in the technic of the treatment The patient must be questioned in detail as to just how she carried out the treatment A common error is to take the douche while sitting on the toilet The folds and fornices of the vagina do not become distended, and hence the trichomonads are not removed mechanically Some patients lose the tablets from the vagina before they are dissolved This can be avoided if the tablet is inserted after the patient is in bed for the night One patient whose condition did not improve was found to be lubricating the tablets with vaseline The tablets did not dissolve and were quickly lost from the vagina Some patients cannot overcome their reticence about douching during the menstrual period They must be reassured that it is not harmful and that it is necessary for successful treatment

The problem of the unmarried girl is more difficult If the hymen does not admit the douche tip, a rectal tip may be substituted In some cases it may be necessary to do a preliminary vaginal dilation or hymenotomy before treatment can be carried out Douching is usually not done as skillfully as in older married women More prolonged treatment is often necessary

If the patient has carried out the treatment in every detail without success, more strident measures should be taken Powder insufflation of the same drug may be necessary weekly or twice monthly Douches must be taken more than twice a day during the menstrual period Just after the period, douches should be taken twice a day and tablets inserted three or four times a day It is a good plan to use an occasional douche and tablet after successful treatment has been completed This is especially important the first few days after the menstrual period

Patients past the menopause are easily cured of *Trichomonas* infections. The senile vaginitis frequently associated with the condition improves with the use of the floroquin tablets. It may be necessary to supplement the treatment with organic or synthetic estrogens for a period of time to improve the vaginal epithelium. A vinegar douche and one or two tablets daily for six weeks will usually be sufficient.

# A REVIEW OF THE VAGINAL SMEAR METHOD FOR EARLY DIAGNOSIS OF CANCER

## A Report of 170 Cases

GEO WM McCLURE AND RICHARD B CATTELL

PAPANICOLAOU first described a technic in 1928 for the detection of uterine malignancy by means of smears from vaginal secretions. Since then the method has been used and described by Papanicolaou and Traut in their illustrated monograph. Meigs and his associates have published a similar report. They claim that a diagnosis can be made by this procedure in 95 to 98 per cent of untreated cases of carcinoma of the cervix and in 90 per cent of cases of adenocarcinoma of the fundus. In some cases more than one smear taken at different times may be required to establish the diagnosis. Papanicolaou and Traut, Meigs and others stated that an unexpected and important feature of this method is the demonstration of cancer in its earliest manifestations of symptoms or before a lesion is clinically obvious. This method, according to them, has also demonstrated cancer when the reasons for symptoms remain obscure even after biopsy and curettement have been carried out.

We know that cancer of the cervix and the body of the uterus is a curable condition provided early diagnosis can be made. Today only eleven of 100 women with cancer of the cervix reach the surgeon when the lesion is in the early operable stage, twenty-nine are in the stage of so-called borderline operability, while in sixty the lesion is totally inoperable when the patient is seen by the surgeon.<sup>2</sup> Thus, delay by both patient and physician is responsible for a majority of deaths from cervical and uterine cancer. A technically simple method of making an early diagnosis of uterine cancer in the daily office practice would aid greatly in the early discovery of uterine malignancy. If this work is proved reliable, it would be a practical method of early diagnosis when placed in the hands of the practitioner.

Our smears were taken from the cervix of women over thirty, regardless of their complaint. Since the vaginal smear is not of value when taken directly after douching, we decided to take cervical smears. The technic is simple. The equipment necessary is a closed jar to hold a slide containing a fixing solution of 50 per cent each of 95 per cent alcohol and ether, a glass slide, a glass writing pencil, diamond point, and a cannula about 8 inches long which may be either glass or metal.

We use an insufflation cannula, size 6 French, with a ball tip with an end opening. Upon this is placed a rubber bulb for sucking up the secretion. We have had a glass tube made, as shown in Figure 263. The advantages of this are: the tube has two side apertures and it is inexpensive, thus it is possible to have several sterile and dry tubes on hand. The slide is marked with an identifying number or name. The patient is placed in lithotomy position and a speculum used. It is better not to use much manipulation, and the smear should be made before manual examination. The cannula is sterilized and thoroughly dried before it is used. When the cervix is brought into view the cannula is inserted about 1.5 to 2 cm., the bulb having been compressed before insertion. The cannula then is slowly withdrawn as the compression on the bulb is released. The secretion is forcibly ejected upon the slide. The smear is smoothed and thinned with another slide, as in making a blind smear, and dropped at once, before drying, into the fixing solution. The smear should be fixed for at least five minutes,

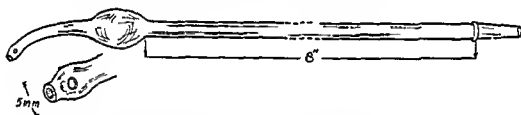


Fig. 263.—Glass tube designed for collection of cervical smears. The bulb is attached to the end of the tube.

but may be kept in the fixing solution indefinitely until brought to the pathologist.

It is important in taking the cervical material for the smear not to traumatize the endocervical canal or cause appreciable discomfort or pain to the patient. From this standpoint the instrument should not be compared with any endometrial aspirating curet such as that used in performing endometrial biopsies at which time trauma is always present.

The fluid of the uterine cavity is obtained by suction and retains its normal cytology. Compared to the vaginal smear, Papanicolaou claims the uterine smear shows a larger number and greater variety of endometrial and cervical cells. As a consequence, the diagnosis of cancer of the cervix as well as of the fundus is greatly facilitated. The method was described earlier by Papanicolaou as vaginal smear. It has the advantage of being very simple to take and can be carried out by the patient or a nurse as the instrument enters only the vaginal vault. However, we believe the cervical smear is a very simple office pro-



cedure for any physician and the cells seem to be more uniform than in the vaginal smear.

The diagnosis of cancer of the uterus by these smears is based on the fact that, like all the epithelial tissues of the body, the superficial cell layers of the tumor are subject to continuous exfoliation. Exfoliated cells mixed with secretions of the uterus and cervix find their way into the vagina and may be recognized in a smear of vaginal fluid. It was demonstrated by Foot that malignant cells can be recognized in fluids from body cavities, as for instance pleuritic and abdominal fluids. The rate of exfoliation is variable. Certain types of uterine cancers, such as adenoma malignum, do not shed as readily as others. The number of exfoliated cells depends upon the type and the developmental stage of the tumor as well as upon the existence and extent of the discharge. It is, therefore, evident that in a smear prepared from fluid obtained directly from the endocervix or from the uterine cavity, the chances of finding exfoliated cancer cells is much greater than in corresponding smears prepared from the vaginal fluid. The vaginal smear has the advantage of being easily prepared with fluid which can be obtained without inconvenience or danger to the patient, as previously explained. In this report the diagnostic criteria to recognize the typical and atypical cells of carcinoma will not be considered, the reader is referred to the monograph by Papanicolaou, with its colored specimens.

The slides from our patients were examined by Drs. Shields Warten and Olive Gates, pathologists of the Laboratory of Pathology of the Harvard Cancer Commission and the State Tumor Diagnosis Clinic.

Of the 170 cases in which smears were made, they were reported as follows: (1) frankly positive, (2) atypical cells suspicious of carcinoma advise further study as a repeat smear or biopsy, and (3) negative. Of the total, 146 cases were negative, five were positive and nineteen were atypical, needing further attention and study. Of this total of twenty-four cases in which further study was needed, six patients were in the thirties, seven in the forties, ten in the fifties, none in the sixties and one in the seventies. Of the twenty-four cases with suggestive findings there were seventeen with positive gynecologic findings and seven with no gynecologic findings.

#### REPORT OF POSITIVE CASES

**CASE I**—A woman, thirty-nine years of age, first came to the Clinic in February, 1945, because of pelvic inflammation. There was no history of carcinoma in the family. In September 1944 a vaginal discharge of white mucus streaked with blood had developed, associated with bilateral lower abdominal pain. A previous diagnosis had been made

of pelvic inflammation, acute endocervical inflammation, associated with disease of the adnexa. She had been hospitalized in November and treated with sulfa drugs and penicillin. The bloody discharge continued and she was then referred to the Clinic.

Vaginal examination showed the cervix to be irregular, the uterus was fixed and very tender to motion, and normal in size. The laboratory diagnosis of the smear was frankly positive. Dilatation and curettage and biopsy were done and the two specimens were reported (1) epidermal carcinoma, ungraded, and (2) epidermoid carcinoma, grade 2. She is now receiving radiation treatment.

**CASE II**—A woman, aged forty-five years, came to the Clinic because of irregular menstrual flow. There was no history of cancer in the family, she had one child, with normal delivery. In 1939 she began to have menorrhagia. The periods became longer in duration, and there was always a copious flow. She had been cauterized in 1937 for 'ulcers of the cervix'. She gained 40 pounds in weight from 1938 to 1940. In October 1940 dilatation and curettage was performed, and a diagnosis made of chronic, hyperplastic endometritis. She was given injections of ortone. Menstruation stopped for six months and then continued.

The patient weighed 160 pounds. She was given a series of radiation treatments up to November 1944 for sterilization. A vaginal smear was made November 17, 1944, which was definitely positive for cancer. A second smear was made on December 5, 1944, the result was negative. On December 29, 1944, dilatation and curettage was performed. Practically no material was obtained. Because of a small fibroid in the fundus and of the previous positive smear, hysterectomy was carried out. The uterus was small and contained a fibroid, 2 cm in diameter, on the posterior surface. On opening the uterus there was a submucous fibroid on the posterior wall of the fundus. There was no gross evidence of malignancy.

The laboratory report of the operative specimen of the uterus was radiation reaction with small focus of adenocarcinoma in the fundus, leiomyoma and chronic cervicitis.

**CASE III**—The patient was fifty-three years of age. There was no history of cancer in the family. The smear was positive for cancer and a clinical diagnosis was made of cancer. Hysterectomy was performed. The pathologic report was adenocarcinoma.

**CASE IV**—A woman, aged forty-seven years, came to the Clinic because of intermenstrual bleeding for the previous two months, and also pain in the back of the legs. There was no history of cancer in the family. On examination the cervix was inflamed and eroded. The uterus was twice normal size. The fundus was movable. A smear was

positive for cancer. Because this patient had a fibroid, hysterectomy was undertaken. The pathologic report was (1) intramural fibroid, (2) hyperplastic endometritis, (3) chronic endocervicitis, and (4) no malignancy.

CASE V—A woman, fifty eight years of age, came to the Clinic because of gynecologic symptoms. The family history was negative for carcinoma. She had had a full course of radiation during the previous two or three years for excessive bleeding during the menopause.

On examination at the Clinic, the cervix bled easily. There were no masses. The uterus was small and hard. Vaginal smears made January 16 and January 29, 1945, were reported suggestive of carcinoma. A third smear taken in February was reported to be positive. Hysterectomy was performed. The pathologic report was small fibroid uterus, no malignant degeneration was found.

This case is interesting because a full course of radiation had been given and the smear was reported to be positive.

Thus, there have been two failures showing a positive smear, but carcinoma was not found at operation. The nineteen patients with a laboratory diagnosis of atypical cells, suspicious of carcinoma, are under observation.

This series is too small and with too short a period of observation for definite conclusions. There are, however, some suggestive points: (1) Atypical cells not very different from carcinoma cells may be found after the menopause, radiation treatment, or with cervical inflammation at any age. In these groups atypical cells have less significance than in the younger age group without pathologic change. (2) The errors in our cases all belong to this doubtful group. Therefore, a suggestive or positive diagnosis in a patient in any of these groups has not the significance it has during the childbearing age without pelvic symptoms.

It has been urged by those who have done the most work on smears that the diagnosis from the smear should not be taken as final. The reason for this has never been clearly brought out and for this reason the warning has not received the attention it should. From the reports of Papanicolaou and Traut and Meigs, the accuracy of the diagnosis on the smears is as good if not better than the accuracy of diagnosis from a biopsy specimen *unless the specimen is taken from a grossly suspicious lesion*. If their figures truly represent the method, it is difficult to understand why it cannot replace the biopsy. From our experience it seems obvious that error in diagnosis by the smear technique is confined to a small group of patients with disease of the uterus not

necessarily malignant. There is no chance of misinterpretation in diagnosis of smears from women in the childbearing period, with no uterine disease. In spite of the value of vaginal smears, we feel that all positive or suggestive positive smears should be checked by biopsy.

It has also been pointed out that the smear may demonstrate hidden carcinoma, that is, carcinoma without symptoms. We had one such case. In examination of some 3,014 women by this method, Papanicolaou and Traut found only nine cases of hidden carcinoma.

It is admitted by all who have used the method that diagnosis demands a great deal of time and experience. The method has not as yet been shown to be a practical laboratory procedure for general use. We feel that the method should have continued study in a large group of cases.

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4 Skull roentgenograms, determination of basal metabolic rate, blood cholesterol, follicular stimulating hormone, estrin, pregnandiol or androgens.

### AMENORRHEA

If the patient has never menstruated and has long passed the normal age for the menarche, the term primary amenorrhea is used. Secondary amenorrhea connotes an absence of flow after the menses have been established. Oligomenorrhea, or cyclic bleeding at abnormally long intervals, may be embodied for practical purposes in the generic term amenorrhea.

We find it convenient for diagnostic purposes to subdivide primary amenorrhea into two groups

#### 1 PRIMARY AMENORRHEA

##### A With absence of secondary sex characteristics

In this group are those disorders which can often be recognized at a glance or require a minimum of investigation. The most important or pivotal diagnostic data are listed

##### 1 Pituitary origin

- a Tumor—Acidophilic, gigantism, enlarged sella, FSH\*<sup>2</sup> & <sup>3</sup> negative  
Chromophobe, retarded growth, enlarged sella, FSH negative

Craniopharyngioma, retarded growth, suprasellar calcification, FSH negative

- b Hypofunction—Complete or panhypopituitarism without tumor, retarded growth, normal sella, negative FSH, low BMR, normal cholesterol

- c Eunuchoidism—Normal height, increased span, negative FSH (although the production of FSH is deficient, other pituitary factors appear to be secreted)

##### 2 Gonadal origin

- a Eunuchoidism (hypogonadism)—Normal height, increased span, excessive FSH (deficient ovarian response)

- b Agonadism—Subnormal height, stocky, pubic hair usually present, excessive FSH, congenital absence of ovary, Turner's syndrome, castration in childhood by disease or surgery

##### 3 Thyroid origin—Myxedema or cretinism—Retarded growth and mental development, low BMR, high cholesterol (normal FSH)

##### 4 Late onset of puberty—Family history

Bone age is retarded in all of the above symptoms

\* Following the technic of Heller and Heller for distinguishing between a normal and decreased excretion level of follicle stimulating hormone,

a negative FSH indicates a decreased excretion level,

a normal FSH indicates an excretion level within the limits of normal,

a positive FSH indicates an excess or increased excretory level.

### B With presence of normal secondary sex development

Here one must exclude an unruptured hymen, an infantile uterus refractory to normal stimulation, congenital abnormalities such as atresia of the vagina or absent uterus

### SECONDARY AMENORRHEA (with the presence of secondary sexual development)

Under this heading are considered the following

- 1 Pregnancy
- 2 Pituitary origin
  - a Tumor—Acidophilic—Acromegaly, enlarged sella, LSH negative  
Chromophobe or mixed, enlarged sella, visual defect,  
FSH negative (secondary sex characteristics may disappear)  
Basophilic—Normal sella, clinical features identifying,  
normal or negative LSH
  - b Acquired panhypofunction—Simmonds' disease and postpregnancy, normal sella, negative LSH
  - c Acquired hypofunction of LSH cells—Negative LSH, no hot flashes, normal sella
- 3 Ovarian origin
  - a Menopause, excess FSH
  - b Tumor—Arrhenoblastoma—Masculinizing, increased androgens, decreased FSH<sup>2</sup>
  - c Hyperhormonal (ovarian)—Persistent follicular cyst—Excess estrogen, later excess FSH  
Persistent corpus luteum—Positive pregnandiol, excess FSH and often false positive A-7 test
  - d Hypohormonal—Unilateral oophorectomy, contralateral ovarian section
  - e Disease of ovary preventing normal function—Normal or increased FSH
- 4 Uterine origin—Lack of uterine response acquired during course of previously existing endocrine amenorrhea
- 5 Thyroid origin
  - a Hyperthyroidism—Goiter, history, elevated BMR, normal FSH
  - b Hypothyroid—Myxedema, low BMR, high cholesterol, normal FSH
- 6 Adrenal origin
  - a Tumor—Cortical—Excess androgens, masculinization (FSH<sup>2</sup>)
  - b Addison's disease—Water test, normal FSH
- 7 Nutritional—Malnutrition with or without systemic disease including anorexia nervosa, FSH normal or decreased  
Excess obesity, FSH normal
- 8 Nervous shock (hypothalamic) or mental disease (schizophrenia), FSH normal or negative

The treatment of the syndromes under Group I-A will not be described here except to state that gonadotropic therapy may be attempted in eunuchoidism with negative FSH tests. Treatment for ab-

sent ovarian function is best carried out with daily or periodic oral administration of stilbestrol or other estrogens

As shown above, premature menopause, persistent corpus luteum, unruptured follicle and selective deficiency of FSH can be reasonably ascertained by endometrial biopsies or hormonal studies. Pituitary tumors can be demonstrated by roentgenogram and thyroid disorders by history and physical examination. The presence of obesity or malnutrition or a history of nervous shock does not necessarily mean that such is actually the cause of amenorrhea.

Not infrequently none of the above causes can be positively determined in cases of amenorrhea. It is in these cases when no decision as to cause can be made that the term functional amenorrhea is loosely applied. Until more practical measures for routine clinical diagnosis are forthcoming, this group will continue to be one in which trial and error methods will have to be employed when necessary.

Before contemplating glandular therapy it is well to reconsider nervous influences producing amenorrhea. Change of environment, such as entering college, or some emotional disturbance in the background may be the causative factor.

Amenorrhea of undetermined origin, usually of secondary type, is not detrimental to normal health and there is no indication for therapy unless (1) a girl has failed to menstruate by the age of seventeen or eighteen years. (In this instance the family history should be closely evaluated. We have recently seen a patient of twenty one entering puberty, with several members of her family having started at the same age.) (2) The psychologic effects of amenorrhea appear detrimental to the patient's well being. (3) Pregnancy is desired.

The objective, therefore, in this type of case is to produce ovulation. Present day treatment is not likely to attain this goal. However, with repeated courses of therapy, general therapeutic measures and close observation over a long interval of time, an occasional case will respond favorably.

Therapy for functional amenorrhea may be attempted along the following lines:

1. A trial of progesterone may be carried out, especially if cystic ovaries are not thought to be present, a total of 50 mg. intramuscularly in divided doses over a four or five day period may be administered. If bleeding follows, it is strong evidence that there is endometrial proliferation and failure of corpus luteum formation. If no bleeding follows, it indicates inadequate or no endometrial proliferation or possibly persistent corpus luteum. Vaginal smears or pregnandiol determinations should be helpful in determining the latter.

2 In cases of delayed menses not due to pregnancy or glandular disturbance, menstrual flow may be restored by the injection of 1 mg of prostigmine. The use of prostigmine does not interfere with pregnancy.<sup>2</sup>

3 In the young girl with amenorrhea of at least four to six months, without response to progestin as carried out above, it would appear wiser to make an attempt to initiate a normal cycle by substitution therapy with estrogen and progesterone given cyclically over a period of at least four months

5 mg of stilbestrol	} Intramuscularly for four consecutive days
10 mg of progesterone	

Bleeding will usually occur in two or three days. Injections should be given for three successive months starting on the twenty-second day after the first day of the flow. Stilbestrol may actually cause some pituitary stimulation, as suggested by the work of Smith.

When it is inconvenient for the patient to receive injection therapy, the following oral program may be employed during the second, third and fourth months. Five tenths milligram of diethylstilbestrol is advised daily from the first day of bleeding until the twenty-seventh day. The daily administration of 10 mg of pregnanolone from the fourteenth to the twenty-first day and 20 mg from the twenty-first to the twenty-seventh day will usually cause a sufficiently secretory endometrium to allow bleeding to occur in two or three days.

4 If no results are forthcoming with these procedures, gonadotropic therapy may be employed. Equine gonadotropin, 400 I U, may be given by intramuscular injection for four successive days and 1200 I U administered on the fifth day. This is followed by 200 I U of chorionic gonadotropin for ten consecutive days in the hope of maintaining a newly formed corpus luteum. Repeated pregnandiol determinations should be done during the early phase of chorionic gonadotropic therapy, and an endometrial biopsy is performed on the first day of bleeding. Should these tests indicate that ovulation has occurred, the patient is merely observed the following month as to her progress. If menstruation has failed to occur, three courses of therapy may be administered with rest intervals of four to six weeks to prevent antihormone formation.

If amenorrhea persists, it may be assumed that the functional activity of the ovaries or endometrium or both is seriously impaired and further therapy, if felt indicated, may then be employed as in 3 (see above).

5 Dilatation and curettage may restore normal rhythm in some cases, either by removing a nonresponsive endometrium or possibly stimulating the anterior hypophysis.



6 Mazer and Greenberg have recently reported an additional ninety-two cases of amenorrhea treated with low dosage irradiation to the pituitary and ovaries, with successful results in 72 per cent of these cases. We have had no experience with this procedure.

7 Patients with a persistent corpus luteum, as shown by a secretory endometrium, a positive pregnandiol determination and possibly a positive A-Z test, as well as persistent cysts of the ovaries are benefited by surgical removal of the corpus luteum or cysts if they do not regress spontaneously.

The administration of thyroïd has long been used in all sorts of menstrual disorders. Its action is probably due in many cases to stimulation of the ovary rather than to any real thyroïd deficiency. Its value is probably over rated.

### FUNCTIONAL UTERINE BLEEDING

Functional uterine bleeding is a term applied to abnormal bleeding which occurs in the absence of organic disease and may be subdivided into

Menorrhagia—profuse or prolonged bleeding occurring at periodic intervals,

Metrorrhagia—bleeding occurring at irregular intervals,

Poly menorrhea—normal or profuse bleeding at regular intervals of twenty one days or less.

A thorough investigation however, is necessary as abnormal uterine bleeding may signify some organic disease or serious disturbance of the endocrine mechanism on which the menstrual rhythmicity depends.

The causes of abnormal bleeding may be satisfactorily classified for diagnostic and therapeutic reasons as follows:

#### 1 Precocious Puberty

##### A Pathologic

Ovarian tumors (malignant teratoma carcinoma granulosa cell tumors)—Surgical removal

Adrenal tumors—Surgical removal

*Lesions of the brain (hypothalamus hypophysis pineal gland ventral cysts encephalitis injuries, polyostotic fibrous dysplasia)*—Treatment hopeless with poor prognosis

B Functional—unusually early but normal puberty—Observance

#### 2 Developmental or Childbearing Period

##### A Myxedema

Acromegaly

Ovarian tumor

Adrenal tumor

- B. Malnutrition
  - Excessive obesity
  - Nervous shock and mental disease (schizophrenia)
- C. Debilitating diseases
  - Inflammatory diseases
  - Blood dyscrasias, chronic nephritis, etc
- D. Congenital anomalies
  - Local causes (myomas, etc.)

In adolescents and women with dysfunctional uterine bleeding therapy as described in 3 (see p 561) may establish a normal cycle

One milligram of estradiol benzoate and 10 mg of progesterone intramuscularly on the twenty first day, followed by 10 mg of progesterone from the twenty-second to the twenty-sixth day, repeated for three cycles may lessen the severity or duration of flow in menorrhagia

Likewise, we have found that large doses of vitamin B complex (12 teaspoonfuls or 12 capsules by mouth daily), as advocated by Biskind, frequently appear to correct a profuse or prolonged flow, at least temporarily. Sufficient time has not elapsed to evaluate its real worth

Turner and his associates have used daily doses of 5 to 12.5 mg of sodium estrone sulfate over a period of two to seven days in women with functional uterine bleeding to produce hemostasis. Good results were obtained by cyclic regulation with sodium estrone sulfate following withdrawal bleeding, the theory being that the tone of the uterine musculature and blood vessels is improved

In polymenorrhea (periods occurring at too frequent intervals and thought due to a premature degeneration of the corpus luteum), 10 mg of progesterone from the eighteenth to the twenty-sixth day for three successive cycles will often result in a prolongation of the intervals between periods

When bleeding is excessive and demands more prompt control, 50 mg of testosterone given parenterally every third or fourth day for three or four doses, followed by 25 mg twice weekly, will usually cause a cessation of bleeding in a relatively short interval. Fifty milligrams of testosterone on the twenty third, twenty fifth and twenty-seventh days may be necessary for a few months to control the bleeding tendency. This form of therapy is not advocated for the adolescent because of the depressing action on the pituitary gonadotropic function and the possibility of masculinizing effects which may occasionally be of a permanent nature

When bleeding occurs after the age of thirty-eight years, a careful pelvic examination and curettage should be done. The results of hor

more therapy are not particularly good. Frequently, the curettage will be found to be beneficial. If the patient is under forty-two years of age and bleeding is uncontrollable, hysterectomy should be performed, but when nearer the menopause, irradiation is preferred. When a hidden malignancy of the corpus uteri is uncovered, total hysterectomy is indicated. Irradiation is employed in cancer of the cervix.

#### MENOPAUSE

Estrogenic therapy is of its greatest value in the management of the menopausal patient. Therapy should be administered only after a careful pelvic evaluation which may indicate the performance of a diagnostic dilatation and curettage. Five-tenth milligrams of diethylstilbestrol is usually a sufficient dosage to control menopausal symptoms and avoid bleeding from overdosage. When symptoms are inadequately controlled and yet estrogenic bleeding occurs, androgens may be given simultaneously in a ratio of

10 mg. of testosterone to 0.5 mg. of estradiol by injection or  
5 mg. of testosterone to 1 mg. of diethylstilbestrol by mouth

Margoliese feels that testosterone constricts the myometrial portion of the spiral arterioles to prevent bleeding and the estrogen limits any masculinizing action.

Lane, in a recent study of menopausal patients, found that estradiol benzoate affords a higher rate of effectiveness but is more expensive and cannot be given orally. He feels that hexestrol phenobarbital therapy is more effective, causes less nausea and is therefore more acceptable than diethylstilbestrol from the standpoint of effectiveness, convenience and economy.

Premenstrual headaches and premenstrual tension can sometimes be relieved by estrogenic therapy. We know of no program of hormonal therapy beneficial to the average patient with dysmenorrhea. If the pain is of sufficient intensity and relief cannot be obtained by analgesics, only a properly executed presacral neurectomy (see p. 518) or a dilatation of the cervix, when indicated, affords satisfactory relief. Endometriosis should be excluded.

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## THE MANAGEMENT OF STERILITY

A SEYMOUR PARKER, JR

To appreciate fully the problems in sterility, one must constantly keep in mind the complicated mechanism of normal reproductivity and the multiplicity of minor and major functional and organic abnormalities that may occur in this physiologic process which nature for the most part so admirably regulates

From a clinical standpoint, the failure of reproductive capacity in the majority of cases is not the result of a single abnormality in only one partner but rather the result of several factors, often minor, in both partners, each of which lowers the fertility, the sum total of which produces sterility or the failure of the couple to reproduce

It follows that in order to evaluate the individual case properly, a thorough investigation is essential to reveal all the etiologic factors involved This demands the complete cooperation of both partners They should be impressed with the complexity of the problem and the necessity for thorough and repeated examinations It is my purpose to outline the basic program now in use at the Lahey Clinic for the investigation of fertility, a plan which we believe is both reasonably simple and effective

### EXAMINATION OF THE MALE PARTNER

**History and Physical Examination**—It is our custom to endeavor to have the male submit to a general examination at the earliest possible date, although he may refuse to do so or (quite frequently) does so with considerable reluctance This examination is of paramount importance when one realizes that 12 per cent, or one in eight marriages in this country are infertile, and in at least one half of these matings the husband is either directly or indirectly responsible

In taking the history of the male partner, inquiries are made as to normal development in youth, previous illnesses, habits and general health, trauma or operative procedures that might possibly affect the genital organs Mumps after puberty, tuberculosis, gonorrhea, syphilis, unexplained or prolonged fevers and prostatitis with their sequelae are particularly sought for Overwork, exposure to chemicals or radiation now in use at various war plants high pressure with associated social obligations, and overindulgence in alcohol and tobacco are frequently associated with nervous fatigue, lack of libido infrequent intercourse and impaired spermatogenesis

In a comparatively small number, the physical examination reveals some major factor in sterility, such as undescended testes, testicular atrophy or endocrine dysfunction. However, such factors as obesity, low metabolic activity, and mild anemias occur more frequently and should be corrected when found.

**Collection of Semen and Its Examination**—Following the complete physical examination, the necessary laboratory procedures are obtained and the patient is given instructions as to the mode of obtaining a sperm specimen, with the specific request that the wife bring the sample to the Clinic for complete examination and a Kurzrok-Miller test, which will be discussed later.

After three days of abstinence, the coital specimen is collected in a clean and dry glass container from which the material is immediately transferred to a sterile test tube with cork top, which is supplied to the patient. He is advised to have his wife bring the specimen to the laboratory with the test tube on her person so as to maintain the fluid at body temperature, the sample reaching the Clinic within an hour after it is obtained.

The examination of the semen is a laboratory procedure which can be carried out after a little experience. As soon as the specimen is received the viscosity is estimated by stirring the solution in a test tube with an applicator and judging the tenacity when the applicator is withdrawn above the surface. A thick ejaculate hampers the progress of the sperm and thus much of its resources will be utilized in moving through this medium. The volume, an index of the contents of the vaginal pool and therefore the contact of the ejaculate with the cervix, can be determined by drawing the specimen into a graduated 10 cc pipet by means of a rubber suction bulb. The most important feature of the examination is the sperm count which is made by diluting the specimen 1:20, using a 5 per cent solution of sodium bicarbonate and making the count on a hemocytometer. Five blocks of 16 squares are counted and six ciphers are added. An average normal specimen contains approximately 100,000,000 spermatozoa per cubic centimeter, 75 per cent of which must be mature and well formed, and at least 70 per cent exhibit lively activity. In the course of hours under laboratory environment, it will be noted that the motility normally diminishes to 5-10 per cent in twenty four hours, finally reaching a state of simple undulation. Some degree of infertility is indicated if the specimen does not meet these standards. Every effort is made to estimate the percentage of morphologic abnormalities<sup>11</sup> as an excess is of the greatest significance and strongly suggests some constitutional disorder.

**Vaso-epididymostomy.**—With a total absence of sperm on examination of at least two specimens, a testicular biopsy rather than puncture is performed to distinguish between atrophy of the seminiferous tubules and bilateral obstruction of the epididymides. Should normal spermatogenesis be present and sperm found in the epididymides, a vaso-epididymal anastomosis may be technically possible. Hagner reported forty-five such favorable cases with twenty-six cures, of which only six patients subsequently had children. Ewert, of the genito-urinary department of the Clinic, has recently informed me that the wife of one of his patients had recently given birth to a normal child subsequent to the performance of this plastic procedure on her husband. Although the results of this operation are none too promising, it is advocated in the favorable group since it offers the only hope for remedying this very uncommon but otherwise hopeless situation.

#### EXAMINATION OF THE WIFE

**Gynecologic History.**—A wealth of valuable information may be obtained from a carefully taken gynecologic history of the female partner.<sup>10</sup> This includes inquiry as to development during puberty, the time and duration of the marriage, former pregnancies with their sequelae, and the use and type of douches and contraceptives employed. Investigation regarding childhood diseases such as mumps and scarlet fever, as well as gonorrhea, tuberculosis, syphilis, malaria and unexplained fevers in the adult should be made. Particular search should be made for any former intraperitoneal disease which might have affected the ovaries or tubes, peritonitis complicating appendicitis or pelvic adhesions secondary to any lower abdominal operative procedure.

The menses are a fair index of the reproductive development of the patient and should be most carefully evaluated.<sup>6</sup> The age of onset, the periodicity and amount of discharge, the character and location of pain and any symptoms of the midcycle should be recorded. Irregularities are worthy of close attention as they may indicate ovarian dysfunction. Likewise, periodic bleeding, while usually indicative of normal ovarian function, does not preclude the possibility of anovulatory cycles.

An inquiry should be made as to any difficulty with the sexual act and the customs of the female partner following intercourse. Frequently there is leakage and the patient customarily gets up for cleansing purposes.

**Physical Examination.**—When the complete physical examination is undertaken, attention should be directed to the height and weight, the general development and bodily configuration. It appears that

women who are unduly obese are prone to menstrual irregularities. Undernutrition should be investigated and the diet checked with regard to adequate protein, vitamin and mineral intake. The conformation of the pubic hair and the presence of excessive hair may represent some masculinizing tendencies but these are usually of no importance unless associated with other findings.

Examination of the external genitalia may reveal inadequate development of the female organs, a tendency to masculinity evidenced by excessive enlargement of the clitoris, or inflammation of Skene's or Bartholin's glands may be evident. Hymenal atresias, vaginal septa or absent vagina are rarely encountered. Failure to retain the deposited semen may result from anomalies of the perineum, a thick pubic arch or a shallow vagina as seen in infantilism. Dyspareunia, a common factor in infrequent coitus, is sometimes the result of tender hymenal rests, although usually it is of psychogenic origin. Vulval and vaginal inflammation or fixed uterine displacements secondary to some preceding infection may also cause dyspareunia.

Sterility may be traceable occasionally to such barriers as thick, tenacious endocervical secretions, a narrow, elongated and stenotic cervix or to chronic endocervicitis. Patency of the cervix may be demonstrated during the course of the uterorubography or endometrial biopsy.

A number of other gross abnormalities may be detected on the pelvic examination. It is rarely necessary to correct uterine malposition and only occasionally does it remain unremedied by such conservative measures as pessaries and position of coitus. Uterine fibroids, thickened adnexa and cystic ovaries are of paramount importance. In cases of doubt, and there are frequent instances, the patient is requested to return for a further pelvic examination following an enema. We do not hesitate to ask the assistance of the surgical department to aid in the correct interpretation of any questionable pathologic findings. When the pelvic examination is inadequate or the interpretation is clouded by different opinions, the procedure is repeated under anesthesia just before the expected menstrual flow, at which time an endometrial biopsy is also performed.

**Kurzrok Miller Test**—The next procedure is the performance of the Kurzrok Miller test.

As has been mentioned previously, the wife is instructed to bring the test tube containing the ejaculate to the Clinic within an hour after it is obtained. She is then placed in the lithotomy position and, with the aid of a nonlubricated speculum, a drop of cervical mucus is aspirated and placed on a clean dry slide. A drop of semen of similar



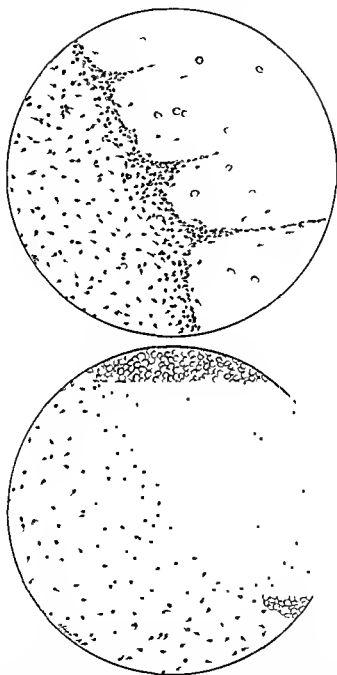


Fig 265.—Kurzrok-Miller test *Upper*, Orientation and penetration of spermatozoa at zone of contact with normal cervical mucus

*Lower*, Failure of penetration of spermatozoa because of infected cervical mucus

size is then placed in close proximity to it. A second slide is laid directly over the first so as to avoid any side to side motion. A distinct boundary under the microscope at high power will then be observed. Normally the spermatozoa gather at this border in rows two to four deep, with their heads pointing toward the mucus (Fig 265, a). At many points the spermatozoa begin to invade the cervical mucus in the form of a triangle. The advancing column may then split and each division advance separately in different directions.

The object of this procedure is to test the ability of the sperm to penetrate the cervical mucus plug and it offers a direct means of comparison in those instances in which therapy has been found necessary. If the cervical mucus is infected or too viscous, there will be no accumulation of sperm at the border and no attempt made to penetrate the mucus (Fig 265, b). This failure of migration of the sperm is also found in the cervical mucus from a hypoplastic uterus. In the latter case, 10 to 20 mg. of stilbestrol given one week prior to a repetition of this test will frequently result in a positive Kurzrok-Miller boundary test. The procedure is used in conjunction with the Huhner test and is particularly indicated when large numbers of motile sperm are found in the vagina but none in the cervical secretions.

**Huhner Test**—The Huhner test has proved to be a simple and valuable procedure. The only essentials are a long bulb syringe, a microscope, slides and a cover glass.

The patient is instructed to empty her bladder and rectum before intercourse and to report to the Clinic within two hours after coitus without taking a douche. She may wear a pad for esthetic reasons. She is then placed in the usual lithotomy position and by means of a non-lubricated bivalve speculum, the cervix is exposed. A sample of the secretion from the vaginal pool is aspirated by means of the bulb syringe, placed on the distal end of a clean slide, and covered with a cover glass. Mucus from the endocervix is then aspirated, deposited on the opposite end of the slide, and likewise covered with a cover glass. Both specimens are immediately studied under the microscope.

Valuable information is obtained from only a few minutes of observation. If numerous and lively sperm cells are found in both samples, such factors as the position of the cervix, whether the vagina is unduly short or long, whether the couple assumes the proper position during intercourse or there is leakage following coitus, need not be considered. We know that neither the vaginal nor the cervical secretions are inimical to the viability of the spermatozoa and that premature ejaculation, epispadias or hypospadias are not the causative factors of the sterility, for lively spermatozoa have reached their destination.

From the information obtained from the foregoing procedure, the following conclusions may be derived

1 If the sperm cells are ample and of normal motility in both the vaginal pool and the cervix, it may be assumed that there is adequate spermatogenesis and delivery of spermatozoa by the male, these sperm being compatible with the vaginal and cervical secretions of the female partner

2 Should the number and motility of the sperm be diminished or absent in both vagina and cervix, there may be (a) inadequate or absent spermatogenesis, (b) failure of or incomplete intromission, or (c) partial or total loss of the sperm

3 If the sperm as visualized in the vaginal sample are normal, yet their number and motility are lessened or absent in the cervix, it may be concluded that some obstruction exists between the cervix and vagina (cervicitis or a cervical plug) or the husband is guilty of imperfect intromission

4 The number of sperm may be normal in both vaginal pool and cervix, but no motility observed in either instance In such a case, either the sperm are nonviable or the vaginal and cervical secretions are lethal to these cells

5 Lastly, the spermatozoa may be amotile only in the cervix, in which instance the cervical secretions of the female are hostile to the sperm

**Uterotubography (Hysterosalpingography)**—It is our custom after treating minor factors such as endocervicitis to refer the patient to the radiologist on approximately the ninth day after the first day of a period for a uterotubogram or roentgen demonstration by radiopaque medium of the anatomical features of the uterine cavity and fallopian tubes

**Technic**—The patient is instructed to take an enema the night before the test, and a cleansing douche the morning before she comes to the Clinic for the uterotubogram She is placed in the lithotomy position, the cervix is visualized, cleansed with an antiseptic solution and then grasped with the cervical hook and pulled into view The cervical canal is probed to determine its length Any excess mucus in the cervical canal and uterus is withdrawn with the cervical tube suction apparatus (Fig 266) The rubber tip of the pressometer is then adjusted so as to allow the injecting apparatus to enter the cervical canal at the proper length, as estimated by the measurement To keep the uterus in a relatively fixed position tension is maintained by pressing in on the pressometer and simultaneously pulling downward with the cervical hook The lipodol is then instilled under pressure which

should not exceed 180 mm of mercury as demonstrated on the manometer. Of more importance, however, in the control of this pressure is the amount of pain which is experienced by the patient. If this is excessive, the examination should be delayed for a brief period as frequently moderate spasm of the internal uterine sphincter will be encountered which will subside spontaneously, allowing the uterus and the fallopian tubes to fill normally.

After instillation of approximately 10 cc of lipiodol, roentgenograms of the pelvis are made. The pressometer is kept in place until these

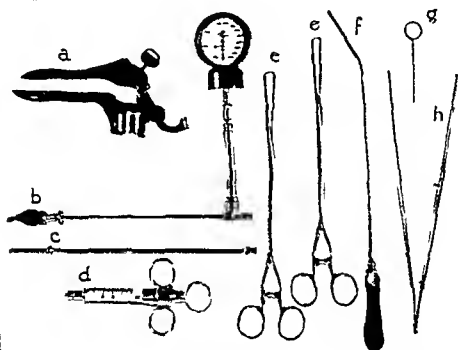


Fig 766—Apparatus for uterine injection for uterotubogram *a*, nonopaque speculum *b*, pressometer assembled without syringe attached, rubber cervical adapter adjusted, *c*, cervical suction tube *d*, locking syringe, *e*, cervical hooks *f*, uterine sound *g*, stilet for cervical tips, *h*, long forceps (From Foster, F L, Surg Clin N Amer, Vol 21)

films are developed to assure good visualization of the uterus and fallopian tubes. With this knowledge, the pressometer is removed and in fifteen minutes a single film of the pelvis is taken to observe the speed of emptying of the uterus. The patient is then directed to return in twenty-four hours to determine the amount of lipiodol remaining in the uterine tubes and also to determine its presence in the peritoneal cavity.

There are certain contraindications to the performance of uterotubography which must be kept constantly in mind. Any subacute inflammatory process along the genital tract is an absolute contrain-

dication and should the sedimentation rate be elevated, this procedure is postponed. The test must not be performed when bleeding has occurred recently or immediately after dilatation and curettage, for the

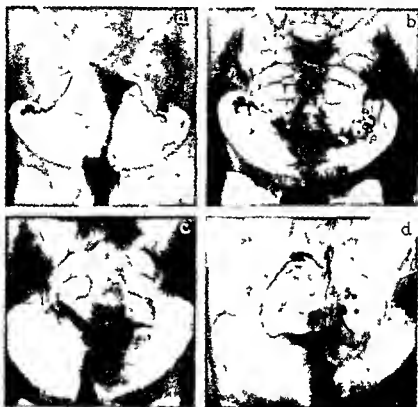


Fig. 267—*a*, Normal uterotubogram with bilateral tubal patency.

*b*, Normal uterotubogram fifteen minutes after injection. Lipiodol disseminated in the peritoneal cavity.

*c*, Bicornuate uterus, single cervix and vagina. Lipiodol is seen passing from the rudimentary right tube (at arrow) into the peritoneal cavity, indicative of tubal patency.

*d*, Normal uterus elongated and displaced, right tube caused by right ovarian cyst. There is linking of the left tube with droplets free in the peritoneal cavity, revealing left tubal patency.

seeds for a subsequent endometriosis may be sown. If any cause has been found to make pregnancy undesirable, such as tuberculosis, no further tests, of course, are warranted.

By means of lipiodol instillation and stereoscopic views, the diagnosis of congenital anomalies of the cervix or uterus (Fig. 267, *c*), an infantile uterus or the degree of anteversion or retroversion can be accurately determined. A feathered appearance of the endocervix is in

dicative of endocervicitis, or a filling defect may indicate a polyp or tumor. Filling defects of a constant nature connote intra-uterine or extra-uterine tumors (Fig. 267, *d*). Rarely, one may see a feathered endometrium which may help to substantiate the diagnosis of uterine hyperplasia.

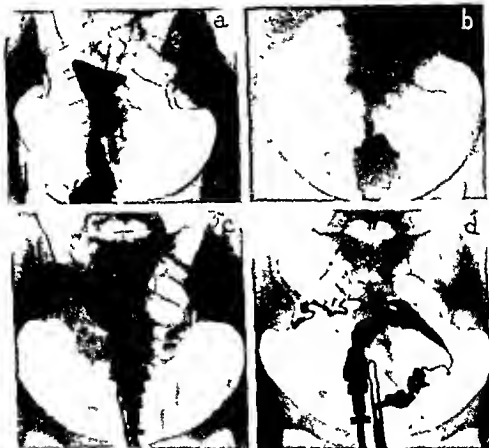


Fig. 268—*a*, Hysterosalpingogram showing normal uterus and bilateral tubal occlusion at the cornua

*b*, Hysterosalpingogram with right tubal occlusion at the cornua, the left tube is of wiry consistency and occluded just proximal to the fimbriated end. Cause, chronic salpingitis

*c*, Right tubal occlusion and irregular defect of fundus (at arrow), consistent with fibromyoma

*d*, Retrodisplacement and lateral deviation of the uterus with isthmic nodosa of the right tube (at arrow)

Abnormally long and tortuous tubes are noted in hypoplasia. Irregular distention, thickened tubes or tubes of wiry consistency are found in chronic salpingitis (Fig. 268, *b*). Distortion and displacement by traction of the tubes frequently occur when pelvic adhesions are present, while hydrosalpinx is diagnosed by droplets within a sac which form a rather coarse emulsion. The uterotubogram is indicated par-

ticularly when there is a history of an old and nonactive pelvic inflammatory process, appendicitis, unilateral salpingectomy, myomectomy, abortion and miscarriage, or when a small fibroid is palpable on pelvic examination (Fig 268)

In those cases in which there are sequelae to old pelvic infections, kinking or tortuosity resulting from malposition, or strictures of a mild degree subsequent to adhesions, repeated insufflations with carbon dioxide often give evidence of improved tubal patency. This test is used in conjunction with hot douches and stilbestrol in an effort to relieve chronic congestion and restore tubal motility. The time best suited for

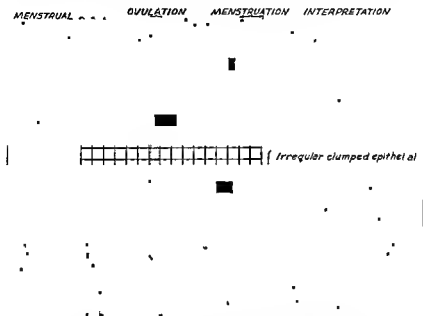


Fig 269 Composite graph outlining the more practical methods to determine the time of ovulation

the performance of uterotubography is about four days after the cessation of menstruation, at which time the endometrium is relatively thin and ovulation has probably not occurred

**Endometrial Biopsy**—Of the means at our disposal, the endometrial biopsy is the most practical in the determination of the presence or absence of ovulation. The vaginal smear, the composite graph of the basal body temperatures for six or seven months and the determination of the pregnandiol complex may be considered complementary to the endometrial biopsy and may be of definite aid in the determination of the exact time of ovulation. Sufficient data have been accumulated from

the recovery of ova, direct inspection during laparotomy and endometrial biopsies to justify the opinion that the fifteenth day before the expected menstrual flow is the approximate time of ovulation, regardless of the length of the patient's cycle (Fig 269)

The endometrial biopsy, a relatively simple office procedure, is performed one or two days before the onset of the period

*Technic*—In performing the endometrial biopsy, the patient is instructed to take a cleansing douche the morning of the test. She is placed in the usual lithotomy position and a pelvic examination is made

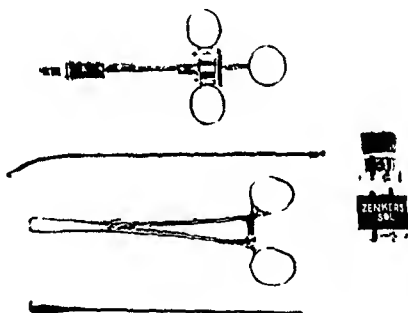


Fig 270—Apparatus needed for endometrial biopsy (From Foster, F L., Surg Clin N Amer Vol 21)

to determine the position and size of the uterine fundus. By means of a bivalve speculum, the cervix is visualized, cleansed by zephiran and grasped by a cervical hook (Fig 270). Occasionally there is some discomfort associated with this maneuver. A uterine sound is placed through the internal os to determine the exact position and depth of the body of the uterus. The biopsy curet is then introduced. Gentle, steady pressure will usually overcome the slight resistance encountered at the internal os. The curet is introduced to the top of the uterine fundus and is then withdrawn making gentle pressure against the uterine wall. Usually three or four strokes in different areas will yield a sufficient amount of endometrium which passes into the barrel of the



curet. These strips are ejected by a syringe onto a small piece of filter paper and dropped into Zenker's solution. The patient is then supplied with a small pad to prevent any staining of the clothing which may result.

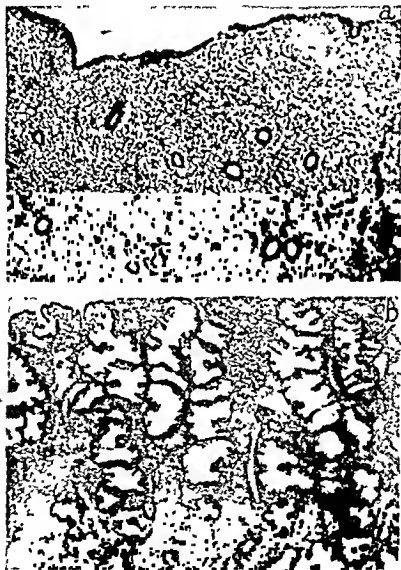


Fig. 271—Endometrial biopsy *a*, Proliferative phase, *b*, secretory phase

If the histologic specimen shows a normal secretory endometrium, it may be assumed that the follicle has ruptured, an ovum was liberated for that particular month, and that the ovary contains a healthy

corpus luteum. Provided the cycles are relatively regular, it appears reasonable to presume that this ovulatory mechanism takes place at monthly intervals. However, certain precautions in the interpretation of the endometrial biopsy must be observed. Since the endometrial surface is not uniformly secretory at any one time, the small uterine curet might have escaped contact with the secretory areas, and if hyperplastic tissue is obtained it is wise to repeat this procedure the following month. It is also a well known fact that certain cyclic bleedings during the course of normal yearly menstruation may be anovulatory (Fig. 271).

#### MANAGEMENT

It would be impractical to go into a detailed account of the various forms of therapy for each abnormality. It may be beneficial, however, to outline a few of the various therapeutic procedures for the three general groups of cases which one encounters in actual practice. This general outline presupposes that a thorough examination has been made and no disease has been found to contraindicate pregnancy.

**Group I Those Couples Married Only a Year or So with Normal Physical Findings and an Essentially Normal Sperm Count**—It is our custom to advise a therapeutic trial of conception with the following instructions:

- 1 The weight should be increased or reduced as the case may be with an adequate protein and vitamin intake.
- 2 Exercise and relaxation should be moderate. Fatigue, excessive tobacco and alcohol should be avoided.
- 3 Written instructions are given on the hygiene of intercourse and the approximate time for coitus in accordance with the patient's menstrual cycle. They are asked to refrain from intercourse for five days before the fertile period.
- 4 Small doses of phenobarbital are administered if there is over-anxiety or tenseness because of failure to conceive.

Basal temperatures may be taken advantageously during this interim and a card shown in Figure 272 is supplied to the female partner, which is a valuable aid to the physician in the event that further therapeutic measures are necessary.

**Group II Those Couples Infertile for a Long Period or Those with Minor or Major Organic Factors**—The therapeutic procedures suggested for this group are:

- 1 Hot douches of vinegar or sodium perborate during the non-fertile interval are advised for leukorrhea, cervicitis and so forth.
- 2 A douche of a 2-4 per cent solution of sodium bicarbonate or of

isotonic glucose in Ringer's solution is advised before coitus during the fertile period when the Huhner or Kurzrok-Miller test indicates such need

3 Occasionally, dilatation and curettage are necessary for endocervicitis or cervical stenosis, and this is done before the menstrual period to obtain an endometrial biopsy

4 Pessaries for retrodisplacement are rarely advised

5 Chemotherapy, pelvic diathermy, stilbestrol and douches are used in cases of pelvic inflammatory disease

6 The uterotubogram is employed as a therapeutic measure and a method to expose hidden anatomical defects. This is followed by carbon dioxide insufflation at repeated intervals during the early phase of

Form 49  
Name *Miss Smith (27-29 day cycle)* Age *31*

Address \_\_\_\_\_ Serv. & No. *1*

Mo	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
Jan					X										✓	✓	✓														X	
Feb								✓		✓	✓	✓		✓													X					
Mar									✓	✓	✓	✓															X					
Apr																																
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*Have intercourse from 10th through 15th night after first day of period.*  
*X = first day of each period.*  
*O = only symptoms during midcycle.*  
*✓ = dates of intercourse during fertile period.*

Fig. 272—Menstrual and coital card

the second week of the cycle if adhesions, kinks or strictures are found, or when all evidence of inflammatory disease has disappeared. Heat and stilbestrol to relieve congestion and increase tubal contractility are also indicated.

7 Myomectomy, tubal operations and so forth, are attempted only as a last resort, and a statistical evaluation of the results is given to the couple before any decision is reached.

8 Uterine suspension is rarely undertaken.

The treatment of the male in this second group consists of such health measures as rest, relaxation, an adequate diet, avoidance of alcohol and tobacco, the eradication of any toxic factor felt to be impairing health, and, when indicated, the treatment of prostatitis or

esiculitis under the supervision of members of the genito-urinary department.

Testicular biopsy is advised in cases of aspermia, and vaso-epididymostomy is undertaken in the favorable group.

It should be mentioned that cryptorchidism should be treated medically or surgically at the age of puberty if spermatogenesis is to take place.

**Group III Those with Predominantly Endocrine Dysfunction<sup>8</sup>**—Any of the preceding factors may also be present in this group. The therapeutic procedures suggested for this group are as follows:

1 Administration of thyroid under supervision will tend to enhance more normal spermatogenesis and oogenesis.

2 Hypoplastic cervixes, uteri and tubes, the result of ovarian underactivity, are often stimulated to further growth, improved secretory and functional activity by estrogenic therapy, and this should be given as a conditioner before the institution of gonadotropic therapy in an effort to stimulate ovulation.

3 An attempt may be made to stimulate ovulation although the results are usually disappointing. Parenteral administration of 200 I U of pregnant mare's serum may be given for five days before the calculated date of ovulation and may be followed for ten days by the daily administration of 250 I U of chorionic gonadotropin. Failure to respond to this form of therapy may be the result of refractory or cystic ovaries, or a thickened tunica vaginalis.

4 In amenorrhea and anovulatory cycles Hamblen has found that the cyclic administration of estrin and progesterone is beneficial in the treatment of sterility.

5 Small dosage radiation to the pituitary gland and ovaries in functional menstrual disorders and sterility has been advocated by several investigators.<sup>1, 7, 9</sup> Our experience with this treatment is limited and inconclusive.

No type of therapy appears to be beneficial to those patients with a persistently positive follicular stimulating hormone reaction and negative estrin reaction.

Testosterone is said to improve a thick and scanty ejaculate by stimulation of the accessory organs but theoretically chorionic gonadotropin should be administered simultaneously to protect spermatogenic function.

Although usually disappointing a combination of chorionic and pituitary gonadotropin may be tried over a period of three or four months in an effort to stimulate spermatogenesis and a comparative sperm count obtained a month after treatment is completed.

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# THE GYNECOLOGIC ASPECTS OF CHRONIC URETHRITIS

LARL L. LAWERT AND OSCAR B. MURRAY

PROBABLY the most common urologic disorder that the urologist treats is chronic urethritis. Some time ago, one of us (F.L.F.), in a paper with Herrold, presented this subject, and we feel, because of the almost universal history that every woman gives of having had at some time an attack of so called cystitis, that reemphasis is worth while.

In contradistinction to the previous paper in which fifty cases were selected from a large group of women this communication deals with unselected cases of women suffering from disturbances of urination. We feel that this would emphasize the role that chronic urethritis plays in the gynecologic complaints of women and more particularly call to the attention of the gynecologist its existence. Urologists have long recognized this condition and have seen many of these women whose symptoms were severe enough and who had endured the condition long enough to seek relief.

It is interesting to note that in this group of fifty unselected cases in which a diagnosis of chronic urethritis was made, thirty-one had had some type of gynecologic operation. Of these fifty patients, forty-five were married, and of these forty-five, twenty-eight had had from one to ten children. We do not mean this to indicate that the urethritis was responsible for the symptoms leading to operation, but we do feel that more attention should be directed to the urinary disturbances which most of these patients had before and after operation.

Directing our attention again at the gynecologic aspects of disturbances of urination in women from the standpoint of chronic inflammatory lesions of the urethra, we realize that although the relationship between the lymphatic drainage of the urethra and the cervix is not conducive to infection by one or the other, the infected cervical glands discharge into the vagina pathogens and this discharge continually bathes the urethral orifice. These organisms work their way into the urethra. The finding of *Trichomonas* and sperm in the bladder urine shows that this is not an uncommon occurrence. It has been demonstrated that certain organisms present in the infected cervical glands have been recovered in the urine of women having intractable urinary symptoms with profound inflammatory changes of the urethra, and no treatment directed at the urethra has had the slightest effect whatsoever.

ever until the infected glands were removed. Occasionally patients continue to have urethral disturbances after excellent cervical plastic operations, and only mild degrees of treatment are needed to obtain complete relief of these urologic gynecologic complaints. The relationship is so intimate between the two that it is not amiss to say that urologists should pay more attention to gynecologic complaints and gynecologists should be more cognizant of urologic disease.

In this group of fifty cases it is interesting to observe that none of the patients had a cystocele deemed by the urologist or gynecologist large enough to require operation.

### SYMPTOMS

The symptoms presented by this group were headed by one complaint which seemed almost universal and that was *urgency*, which in a few instances was to the point of incontinence. In several cases in which there was a high degree of inflammatory reaction in the urethra, the patients were incontinent and it was necessary for them to wear two or three pads a day. Frequency of urination in chronic urethritis takes on several different aspects. In some cases the frequency is unvarying, necessitating urination hourly or even more often both day and night. In other cases in this group there were bouts of frequency that necessitated urination every few minutes for several hours, especially on arising in the morning, and then the frequency decreased so that the patients voided only a few hours apart. Nocturia of one to four times was present in all cases. Terminal burning occurred in approximately three fourths of the patients, and in those in whom frequency was most pronounced, the burning was most intense.

Suprapubic pain or pain referred to the groin, to the vulva, and deep in the vagina was not uncommon in patients having urinary disturbances.

Seventeen patients were undergoing changes characteristic of the menopause and here it is well to remark that at such a time the first attack of chronic urethritis may occur. Emotional instability heightens all of the symptoms, and some complain most bitterly of their annoying urinary symptoms.

Seven patients had atrophic vulvovaginitis of a sufficient degree to cause symptoms in addition to those of the urologic condition. Many patients in this group complained less of the symptoms attributed to the senile changes when attention was directed at their urethral condition.

Six patients had definite urethral strictures produced by acute urethritis probably from the same causes as those occurring in the male.

Three patients had *Trichomonas vaginalis* and the organisms were recovered from the urine

Three women had urethral caruncles at the external urinary meatus in addition to inflammation of the urethra

The duration of symptoms varied from one to ten years the average was two and a half years This is a difficult factor to analyze since many patients had had repeated attacks over a period of years, and we felt that this was not a particularly reliable observation

Thirty five patients were forty years or older, fifteen were in the age group from twenty to forty years

### DIAGNOSIS

The diagnostic procedures employed in all of these cases consisted of studies of the upper urinary tract by means of excretion urograms as all of these women were ambulant and seen in the office Catheter urine specimens were obtained and several studies carried out in most cases Routine Gram stains were made on the sediment in all cases Cystoscopic examination using the panendoscope, in addition to cystoscopic examination of the bladder, was done one or more times in each case and speculum examination of the cervix as well as pelvic examination completed the urologic examination No patient was included in this group in whom pathologic changes of the upper urinary tract were found since this would have introduced extraneous factors

The appearance of the urine in women having symptoms suggesting urethritis is as a rule sparkling clear Only an occasional pus cell or an occasional organism will be found in the centrifuged specimen We believe however, that the urine culture would be positive in a large proportion of these cases if the urine were obtained at the height of an attack of acute urethritis or at the initial attack A good proportion had urinary symptoms which dated from urethral catheterization and they blamed the catheterization as the cause of their urinary disturbance However, in analyzing this it was found that catheterization was carried out in these cases for a bladder which was overdistended or decompensated and that the initial catheterization was instituted only after there had been inability to void for twelve hours or more In these cases residual urine was present during the postoperative course and subsequently a urinary tract infection developed This infection in many instances was the result of chronic urethritis in which the inflammation had persisted no doubt because of infected urethral glands or the production of disease in the urethra such as polypoid excrescences and granulations which produced an ultra sensitive canal that did not permit the bladder to become fully distended The pa



tients henceforth have abnormal frequency, it is most pronounced when they are on their feet and when they become fatigued. If a decompensated bladder results after surgical menopause has been produced many of these patients do not receive the full benefit from their gynecologic operation but continue to complain strongly of urinary frequency and pain in the urethra suprapubically and in the vagina. Because the urine remains sparkling clear the physician may overlook the disease produced in the urethra by a postoperative urinary infection from a decompensated bladder. An understanding of bladder physiology as it affects the postoperative course will enable one to avoid many of the urethra sequelae.

Cystoscopically the urethra shows pathologic change of varying degrees of severity attributable to the intensity of the inflammation or its duration. In the aged female the external urinary meatus is small and turned in by the senile atrophy of the vaginal mucosa. It is necessary to dilate the urethra in these aged females in order to pass a number 22 or 24 panendoscope. Many of these patients had extreme pain on passage of the instrument which was gripped tightly by the urethra and the induration indicated a high degree of inflammation in the canal in some of the cases. The first portion of the urethra usually presents hyperemia with the posterior urethra or vesical end of the urethra showing a granular appearance of the mucosa with inflammatory polyps which seem to start from the edematous folds of the mucous membrane. Tiny loops of vessels can be seen running over the tip of these folds which after a time become polypoid in character. We have seen polyps 1 cm. or longer which fringe the entire bladder neck and are most prominent at the urethrovesical junction. Here the mucosa becomes velvety as it extends onto the small portion of the trigone and the grayish granular appearance of this inflammation is characteristic and is sharply outlined by the edges of the healthy mucosa. This pseudomembranous reaction is usually present during attacks of urethritis and is seen in the early cases. In some of these cases tiny papillomatous tumors will be found in the urethra with sprigs or fronds characteristic of a true papilloma. With the cystoscope in place and the vaginal finger beneath it the urethra can be felt to be thickened, tender and in some instances having the induration so pronounced that when the cystoscope is removed the urethra feels as if it contained a hard tube.

#### TREATMENT

The treatment in most of these patients is simple. Our plan is to calibrate the urethra and dilate the canal once a week or twice a month until the urethra will accept a number 28 to 30 French sound. Follow

ing each dilatation, silver nitrate is instilled, beginning with a 1:1000 solution and never increasing the strength beyond a 1:250 dilution. One has to be particularly careful that the very weak solution is used at first because severe reactions may be produced sufficiently profound to cause the patient to become bedridden for several days. In addition to this, acetic acid douches are prescribed and small doses of belladonna and phenobarbital given at intervals of frequency until response to the treatment is obtained.

For patients who are in the menopausal or postmenopausal stages estrogen is given in addition and sedation is also necessary in most cases. It is in this group that some degree of incontinence is found at times on exertion, laughing or stooping suddenly, and urethral dilatation with instillation of silver nitrate has benefited those patients who do not have evidences of marked birth trauma. Instruction regarding stopping and starting of urination and practice repeatedly during voiding will enable these patients to gain complete control.

Attention is directed at any urinary tract infection and in those patients having an acute urethritis, sulfathiazole or sulfadiazine is given by mouth. It has been our impression that if large quantities of fruit juice or vegetables are taken, producing a highly alkaline urine, the symptoms become more severe. It is the custom for some patients to take sodium bicarbonate for most any ailment, and such treatment frequently increases the severity of the symptoms, cystoscopic examination almost always reveals some degree of trigonitis.

In cases of *urethral caruncles*, unless the caruncle is exquisitely sensitive, urethral dilatations are carried out, and in many instances the caruncular formation disappears following the dilatation and several applications of silver nitrate given locally. Urethral caruncles frequently recur, and we caution those patients who have had urethral caruncles to report two or three times a year to determine whether the urethra is adequately dilated. We feel that destruction of the urethral caruncle alone, with no follow up care so far as vaginal hygiene is concerned, and no attention to any coexisting cervicitis and management of the urethra, will be productive of more urethral caruncles in the future. In no case in which treatment has been directed at the urethra and the cervix has there been recurrence of the urethral caruncle.

The use of stilbestrol in the menopausal and postmenopausal patients having urethritis has been exceedingly helpful. Many of these patients learn to adjust the dosage of stilbestrol and are able to maintain themselves on two or three tablets of 0.5 mg. of stilbestrol at weekly intervals.

## SYMPTOMS AND DIAGNOSIS

Symptoms vary, some diverticula produce no symptoms at all and are discovered accidentally. The common complaints are urinary disturbances, dysuria, frequency and pyuria. Secondary infection and stone formation are common, in which event there may be a purulent discharge from the urethra and even hematuria. Occasionally the patient will note a swelling in the vagina or dyspareunia.

Differential diagnosis includes peri-urethral abscess, solid tumors, cysts which do not communicate with the urethra, urethral prolapse, cystocele and urethrocele. The latter term is sometimes loosely used to designate an urethral diverticulum of the wide-mouthed type, but it should be restricted to those cases associated with cystocele in which there is a prominent bulging of the urethra because of loss of fascial support.

The diagnosis of urethral diverticula is based upon careful examination of the urethra and vagina. Sometimes a second examination is necessary in order to detect a collapsible bulge in the vagina over the urethra since the sac may be empty on the first examination. If urine can be expressed from the mass into the urethra after the bladder has been emptied, the diagnosis is made even without visual intra urethral examination. The diagnosis is absolute after direct visualization through the urethroscope. Oftentimes a careful search is required to locate the one or more orifices of the pouch. The pocket may also be filled with opaque material and then examined roentgenographically to determine the exact extent and position of the lesion.

Diverticula in the male are comparable only in those cases in which they occur in the prostatic urethra posterior of the verumontanum. Obviously, the anterior urethra is not comparable from an embryologic standpoint or otherwise, and its lesions are usually secondary to obstruction or damage to the urethral wall, lesions, incidentally, which are becoming much less common since the modern control of venereal disease. Rarely, a neurogenic case is seen associated with incontinence following prostatectomy.<sup>2</sup>

## TREATMENT

Surgical excision is the treatment of choice in the majority of cases but conservative management may result in symptomatic cures in certain cases. Small, wide-necked diverticula are particularly amenable to periodic urethral dilatation which may be followed by instillation of silver nitrate, 1 to 250 dilution. Not uncommonly, a diverticulum with stone may be treated successfully, as in one of our cases, by intra urethral manipulation followed by urethral treatment.

The large diverticula, especially those with small intra-urethral communications, lend themselves readily to excision. The recommended procedure is as follows. With the patient in exaggerated lithotomy position, the anterior vaginal wall is dissected free over the site of the diverticulum as in repair of cysto urethrocele. This is done preferably through a longitudinal incision. The sac is mobilized and may be opened so as to expose the urethral communication. A catheter may be placed in the urethra as a guide to dissection. The sac is then excised at its base close to the urethra and the urethral defect closed transversely, using interrupted sutures of number 00 chronic catgut. An alternate method of dealing with small mouthed diverticuli has been used by a number of operators. It consists of using a purse-string suture about the stump, followed by inversion of the stump into the urethra. However, this method appears to offer no advantages as far as the end results are concerned and is limited in its application. Plastic repair of the urethrovaginal septum may be necessary in large diverticuli but in the majority of cases simple excision of the redundant vaginal mucosa and closure of the wound without drainage suffices. It is imperative to leave an indwelling catheter in place for a period of ten days after operation and a gauze pack should be placed in the vagina for forty eight hours.

Results from this procedure are reported as uniformly good. Complications such as urethrovaginal fistula, urethral stricture, urinary incontinence and cystocele are remarkably rare.

#### REPORT OF CASES

CASE I—A woman aged twenty-nine years, was seen in the Clinic October 29, 1930. At that time she noted some leakage of urine and also a swelling which presented outside the vagina. Although married fourteen years, she had no children. Hysterectomy had been done previously.

Examination revealed a fluctuant tumor on the anterior vaginal wall along the course of the urethra. Cystoscopy disclosed a pocket-like opening in the posterior urethra just distal to the internal sphincter. The urine was cloudy and loaded with pus cells, but there was no evidence of cystitis and the upper urinary tract was negative. An urethrogram was made which showed outpocketing, approximately 3.5 by 2.5 cm., which arose from the middle third of the urethra somewhat to the left of the midline. In addition there was a secondary outpocketing suggesting an irregularity of the diverticulum, possibly even a small secondary pouch.

On July 23, 1931 with the patient in lithotomy position diverticulectomy was performed. The vaginal mucosa overlying the diverticu-

lum was excised and the sac entered. Since it was adherent to the mucosa from recent inflammation, dissection was difficult and a pocket of thin, watery pus on the left side was entered. The diverticulum was completely excised and the vaginal mucosa sutured together, using a rubber dam in the incision and a de Pezzer catheter in the bladder for constant drainage. Pathologic examination showed no evidence of urethral mucosa in the excised remnants but merely acute and chronic inflammation.

Convalescence was uneventful until the seventh postoperative day when slight bleeding arose from the incision. The rubber dam was removed and slight bleeding continued through the day, becoming increasingly brisk. It did not respond to vaginal packs and the incision had to be resutured in the operating room. The secondary hemorrhage was noted to arise from an area of granulation where the drain was placed. The wound thereafter healed well but a skin eruption developed which was thought to be syphilitic in view of positive Wassermann and Hinton tests.

Postoperatively, the patient had some day and night frequency and dribbling of urine which responded to urethral dilatation and massage of the urethra with a catheter in place. In addition, bladder irrigations with 1 to 6000 silver permanganate solution were given. The patient was entirely asymptomatic when last seen in July 1932.

*Comment:* The fact that no urethral mucosa was found on histologic study does not necessarily rule out a congenital origin in this case since inflammation could have obliterated any signs of mucosa. We do not believe that drains are necessary even in infected cases.

**CASE II**—A man sixty-six years old, came to the Clinic July 27, 1934, complaining of dysuria of two years' duration. He had not had any previous operations. Examination revealed slight prostatic enlargement of the benign type. Studies revealed bladder neck contracture and vesical calculus. There was some shortening of the prostatic urethra and a small diverticulum was seen through the panendoscope just posterior to the verumontanum.

On August 1 suprapubic removal of the bladder calculus, about 2 cm. in diameter, was done. On August 10 transurethral prostatic resection was carried out, with the removal of 2 gm. of tissue. Postoperatively the patient was asymptomatic and consequently nothing was done about the diverticulum.

*Comment:* The origin of this diverticulum is obscure. This case, however, demonstrates a common site for diverticulum in the male.

**CASE III**—A sixty-six year old woman was seen at the Clinic June 18, 1940, because of urgency and frequency of urination and suprapubic pain of eight to ten years' duration, the symptoms of which at first

were periodic but had become almost constant. The patient stated she voided fifteen to twenty times during the day and six to seven times at night. There was hematuria on one occasion. Although married, the patient was nulliparous.

Intravenous urograms were normal although early Paget's osteitis of the pelvis and spine was noted. Cystoscopy revealed a small spastic bladder with diffuse inflammation throughout. Urethral examination showed severe inflammatory changes and as the panendoscope was withdrawn, pus was seen streaming into the bladder. The source of this pus seemed to be a large-mouthed diverticulum just to the right of the floor, apparently distal to the sphincter and approximately 1 cm. from the external meatus. Pressure applied to the urethral region through the vagina caused more pus to well into the urethra. The urine sediment showed 25 to 30 white blood cells and culture revealed the presence of *E. coli*. A diagnosis was made of urethral diverticulum and severe urethrocystitis.

Because the diverticulum itself did not seem to be large and the mouth was ample, it was felt that an attempt should be made to treat the urinary tract infection by dilating the urethra and massaging the diverticulum in the direction of its mouth. These treatments, including administration of neoprontosil in moderate doses and hot sitz baths, resulted in such marked symptomatic improvement that the patient refused to enter the hospital for examination and consideration of operation.

Cystoscopy four months after treatment was instituted showed similar findings except that much less inflammation was present. However, pyuria persisted and on June 6, 1941, the patient returned because of an exacerbation of frequency and dysuria. Again she refused operation and was discharged to the local physician for a course of sulfathiazole and urethral dilatation.

*Comment:* Despite the marked symptomatic improvement in this case from the conservative regimen we felt that operation was probably indicated and should have been insisted upon early.

CASE IV.—An unmarried woman, aged thirty-two years, came to the Clinic October 3, 1940, complaining of almost continuous head and chest colds of two years' duration. The only urinary symptom was urgency which was aggravated when nervous. She had not had previous operations, but there was a history of gonorrhea and syphilis.

Examination revealed a slight vaginal discharge secondary to a mild cervical erosion. The urine contained pus, grade 1, and a few bacilli. Examination of the blood gave negative results and the red blood count was normal. A diagnosis was made of chronic infection of the urinary tract and chronic cervicitis, and the patient was placed on a regimen consisting of douches and administration of urinary antiseptics.

The patient was again seen November 22, 1940. The condition had remained about the same. At this time cystoscopy showed slight diffuse inflammation throughout the entire bladder. The posterior lip of the bladder was somewhat prominent because of a large-mouthed, rather shallow diverticulum opening on the floor of the urethra in approximately the midportion just to the left of the midline. The panendoscope was passed with a little difficulty because of the snugness of the urethra. On the floor of the urethra there appeared to be an eminence suggestive of the verumontanum seen in the male prostatic urethra. There were flakes of exudate in the diverticulum but the remainder of the urethra was normal except for some evidence of chronic inflammation. A diagnosis was made of chronic urethrocystitis and small diverticulum of the urethra. Conservative treatment was advised because of the shallow, large-mouthed type of diverticulum, and the patient was placed on a regime of urinary antiseptics with urethral dilatation followed by instillation of silver nitrate, 1 to 500. After nine treatments given during the following nine months at successively increasing intervals the patient rapidly became and stayed asymptomatic. The urine was grossly clear although a few pus cells still remained in the urinary sediment.

*Comment.* Evidence of a congenital origin of this diverticulum was counterbalanced by the history of gonorrhea as an etiologic factor.

CASE V.—A married woman, aged forty years, was first seen at the Clinic April 14, 1941, because of kidney trouble of fifteen years' duration. She was nulliparous, but sterilization had been undertaken following ruptured tubal pregnancy in 1929. The kidney trouble consisted of pain in the loin, extending downward and anteriorly into the groin, with occasional chills and pyuria, but no hematuria.

The urine was clear but 8 to 10 white blood cells and an occasional clump were seen in the sediment. Cystoscopy was carried out after dilating a contracted meatus with a number 21 French sound. The bladder was normal except for a pseudomembranous trigonitis. The proximal urethra showed considerable inflammation and in about the midurethra there was a shallow diverticulum on the floor, extending completely from one side to the other. Pressure with a finger in the vagina produced a flow of purulent secretion from this diverticulum. The patient refused operation and was placed on a regime consisting of urethral dilatation and vaginal douches, which resulted in considerable improvement of all symptoms.

Two years later, April 21, 1943, the patient complained of recurrence of suprapubic pain when the bladder was full, a small urinary stream with delayed emptying time of the bladder, and nocturia, times one. The urine was clear although 1 to 3 white cells and 1 to 2 red cells were found in the sediment. Vaginally, the urethra was

felt to be enlarged and tender, with a gritty sensation over the area where the urethral diverticulum was previously found. The urethral stricture was dilated and urethroscopy done. This revealed a normal bladder and trigone. A grating sensation was felt when the panendoscope was passed over the mouth of the diverticulum, but no calculus could be seen. Following cystoscopy, a number 28 French sound was passed and a light massage given over the area of the diverticulum. The stone was soft and fragmented easily. After three or four such treatments associated with small doses of urinary antiseptics the gritty sensation disappeared and roentgenograms on two subsequent occasions failed to show any calcification in the urethra. The patient was discharged October 10, 1944, after remaining asymptomatic for approximately a year.

*Comment.* It will probably be necessary to administer urethral treatment once or twice a year for an indefinite period since the urethral diverticulum was complicated by a mild meatal stricture, which may have been an important etiologic factor.

**CASE VI**—A thirty-nine year old woman, gravida I, was first seen at the Clinic September 22, 1944, complaining of pustules on the face of five years' duration. She also complained of considerable vaginal discharge or loss of urine, especially marked during coitus but she was not sure which. The only other urinary symptom was nocturia, times two.

Examination revealed a firm cystic mass, about 2 cm. in diameter, on the anterior vaginal wall just inside the introitus. Pressure over this area resulted in a grayish, watery discharge from the urethra. A small caruncle was noted at the meatus. The "leukorrhea or urinary dribbling" had not responded to acetic acid douches.

Cystoscopy revealed a small diverticulum on the bladder floor posterior to the right ureteral orifice, but the bladder otherwise was normal. There was marked urethritis which made examination without anesthesia painful. The patient was given two urethral treatments consisting of dilatation and instillation of silver nitrate, 1 to 200, and small doses of sulfathiazole. Urethroscopy was repeated October 25, at which time the mouth of the urethral sac was found approximately 2.5 cm. distal to the vesical neck on the floor of the urethra. By introducing one finger in the vagina and a number 22 panendoscope in the urethra it was possible to dilate the mouth of the sac sufficiently to make an urethrogram.

On January 3, 1945 the urethral diverticulum was excised. The patient was placed in high lithotomy position under spinal anesthesia. A catheter was placed in the bladder and a midline incision was made over the cystic area down through the vaginal mucosa. The two flaps were dissected laterally, exposing the diverticulum. By means of sharp



and blunt dissection the sac was mobilized down to the urethra and excised. The urethral opening was then plicated with two Lembert sutures. The urethra was further reinforced by several interrupted chromic sutures, approximating the submucosal tissues of the urethrovaginal septum. The redundant vaginal mucosa was excised and the remaining mucosa sutured with interrupted chromic catgut. A gauze pack was placed in the vagina for twenty-four hours, and the indwelling catheter left in place for ten days. The patient was discharged, voiding well, on the fourteenth postoperative day. The pathologic examination showed tissue compatible with a diverticulum, with chronic inflammation. Since then the patient has been seen twice and has remained asymptomatic.

#### SUMMARY

Six cases of urethral diverticulum are reported to call attention to a lesion which we believe has been frequently overlooked in the past, especially in women. There is no characteristic symptomatology but an urethral diverticulum should be suspected in any patient with a swelling in the anterior vaginal wall or about the urethra. Direct inquiry should be made regarding such a swelling in any patient with recurrent or persistent bladder symptoms. The treatment of choice is surgical but symptomatic cure may often be obtained by conservative management. The method employed at the Clinic is described.

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## PRURITUS ANI

RICHARD B. CATTELL

PERIANAL itching is one of the commonest rectal symptoms. The patients presenting this complaint are exceeded only by those having hemorrhoids. Many mild cases are found on routine inspection of the anus during general physical examination without the patient having previously spoken of it as a complaint. Many of these patients have had mild intermittent pruritus for years and seemed ashamed to call attention to it while others considered it an affliction they must bear. In serious cases when pruritus ani may interfere with normal work and activity it may be the presenting symptom, disregarding others of more serious import. Most patients with pruritus ani can be relieved of the itch by a relatively simple regimen faithfully carried out.

### ETIOLOGY

In the majority of the patients whom we have observed in the last three years the pruritus has no known cause and can be classified as of the idiopathic type. It tends to be less severe and of shorter duration than in those cases complicated by other conditions. Many causative factors are recognized as producing or contributing to anal itch, the chief among them being anorectal diseases such as cryptitis, fissure-in-ano, fistula in ano, hemorrhoids, simple spastic anal sphincter or fibrosis of the anal sphincter. Patients with anorectal diseases make up the second largest group of the pruritus cases. A number of skin diseases may lead to the onset of pruritus, the chief among them being the diseases due to fungi. *The presence of skin lesions should always be noted and proper steps taken for their treatment.* Food sensitivities and other allergies may prove to be contributing factors.

There are a number of gynecologic conditions that may produce or aggravate pruritus. Acute vaginitis, Trichomonas vaginalis infestation, endocervicitis, lacerations of the perineum and cervix as well as diseases of the fundus and appendages occasionally accompany this symptom. Bowel dysfunction, particularly that associated with cathartic abuse, if not corrected may cause persistence of pruritus and failure of treatment. Poor hygienic care of the anus with frequent trauma to the anus and perianal skin may originate a condition from which the pruritus develops.

Pruritus is common in nervous and fatigued persons, yet no real neurogenic cause can be proved. Obesity is a definite contributing

factor in many cases. Pruritus is occasionally observed in patients with debilitating diseases such as tuberculosis and nephritis, and more frequently with diabetes mellitus.

Except for the mildest cases, nearly all are associated with secondary infection even when the primary cause is a fungus. This secondary infection is such a conspicuous feature in the advanced cases that it may be considered a primary cause.

#### DIAGNOSIS

The diagnosis of this condition is made by the patient and it remains for the physician to determine and eliminate the causative factors. A complete history should be taken and physical examination should be done in all cases. This should include careful gynecologic studies with cervical and vaginal smears when indicated and inspection of the cervix. The prostate should be checked for possible enlargement or infection. All skin lesions should be noted and skin consultations will be required in a considerable number of cases. Careful attention should be paid to a proctologic examination. Inspection of the perianal skin, anoscopic and sigmoidoscopic examinations should be routinely carried out. This is the most important part of the examination since anorectal causes are so frequent.

The laboratory findings are usually negative. The routine urine examination is used to exclude diabetes mellitus and nephritis. Secondary anemia is not often observed. Lues has not been found to be a factor in our cases.

#### TREATMENT

Because of the frequency of pruritus ani and its tendency to recur even with treatment, the methods used for its relief have been legion. Proprietary preparations have had a wide use by patients both before and after medical consultation. Most of the treatments have consisted of topical application of solutions, powders and ointments. We have discontinued all topical applications of preparations having a grease base. Likewise, drying powders have not been found to be efficacious. Radiation treatment was used in many of our early cases but has been discontinued since only temporary relief was obtained. Intracutaneous and subcutaneous injections have been used in the past and all have been discontinued except for the injection of alcohol in cases resisting all other forms of treatment. Division of the nerves crossing the ischio-rectal fossa and undercutting operations have likewise been discarded. Radical excision of perianal skin, similar to the treatment of kraurosis vulvae, is not feasible. In a few of our severe cases we have combined the injection of 40 per cent alcohol with a plastic procedure.

removing segments of perianal skin. We have had no experience with tattooing or cauterization.

The treatment which we routinely use in our pruritus cases is designed to overcome the secondary infection, maintain the perianal skin in as dry a state as possible at all times, and to obtain immediate relief of itching by means of a topical application of some analgesic agent as well as elimination of known causes.

#### REGIMEN FOR UNCOMPLICATED CASES

Sitz baths twice daily, using a warm potassium permanganate solution, are routinely advised. This has been the best means of eliminating infection. In order to relieve the itching a drying solution containing either phenol or nupercaine usually used in the common chlanine lotion is applied as often as necessary, as well as after each bowel movement and before going to bed. Most patients are placed on an ambulatory bowel management and told to avoid cathartics. Tincture of belladonna is given if an antispasmodic is indicated. Each patient is carefully instructed regarding local anal hygiene. The use of toilet paper is discontinued and replaced by moist and dry cotton. Emphasis is placed on avoiding any local trauma. Daily douches, again using the potassium permanganate solution, are advised even in the absence of vaginal symptoms. Finally, a mild sedative is given at frequent intervals at the beginning of treatment but later is discontinued.

This treatment must be faithfully carried out for a period of two months but the topical applications are continued the third month if necessary. Our observation of these patients in the uncomplicated group after this interval leads us to believe that most patients will obtain satisfactory relief.

#### REGIMEN FOR COMPLICATED CASES

The same regimen is carried out in the complicated cases as previously outlined for a period of one month in order to eliminate secondary infection and to obtain as much improvement as possible before carrying out more definitive measures. When indicated, cervical or perineal repair or hysterectomy may then be carried out. Cauterization of the cervix may be done as an office procedure. Anorectal procedures after this interval may be carried out safely, and include anal dilatation always accompanied by pectenotomy or division of the superficial bundle of the external sphincter fibers, injection of internal hemorrhoids with phenol in oil or hemorrhoidectomy. Failure of relief in a case previously thought to be uncomplicated may indicate the necessity for allergy studies or skin consultations. Alcohol injections

will be required in a few cases but the number requiring it has greatly diminished in the past three years. Rarely, a plastic operation will be indicated.

#### RESULTS

We have had approximately 10 per cent failures in our uncomplicated group of pruritus ani. Not infrequently, failure is the result of misunderstanding on the part of the patient in carrying out the treatment. Careful review of the details of treatment with the patient may make the reason for failure apparent. It is important that the treatment not be discontinued because of convenience, and one must make certain that it is carried out throughout the menses. An appreciable number of patients have return of mild itching and resume the treatment as they have been previously instructed. The astonishing thing from the observation of a large group of these cases, many of whom have had extensive treatment before carrying out the regimen that has been outlined, is that there is this high proportion of relief by these simple measures.

#### SUMMARY

A general regimen in the treatment of patients with pruritus ani has been outlined which has given good results. The tendency to recurrence is recognized and if treatment is resumed at once, relief follows. It is important in those cases complicated by other conditions, either of an anorectal or gynecological type, that these conditions be corrected early in the course of treatment. Alcohol injections and plastic operations are necessary in but few of the patients whom we have treated in the past three years.

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# THROMBOPHLEBITIS AND PULMONARY EMBOLISM IN PELVIC SURGERY

JAMES A. EVANS AND MARTIN B. KASSELL

## PROPHYLACTIC MEASURES

THROMBOPHLEBITIS is always considered a special hazard in pelvic surgery, especially following hysterectomy, in which its incidence has sometimes been quoted as high as 6 per cent. Every surgeon proposing any pelvic operation must take cognizance of this risk and practice proper prophylaxis in all cases. Such measures can reduce the incidence to 1.8 per cent, which is our percentage of thrombophlebitis with or without pulmonary embolism during 1944 in patients undergoing all types of major pelvic operations. There was no incidence of fatal pulmonary embolism.

The prophylactic measures are

1 *Dicoumarol Therapy* Prophylactic dicoumarol anticoagulation therapy should be established as soon as all danger of postoperative hemorrhage is past, if there is a history of previous thrombophlebitis whether spontaneous postoperative or postpartum.

2 *Leg Exercises* 'Wiggle the toes and ankles 1000 times a day'. The nursing and intern personnel must be taught to remind the patient frequently to carry out these directions beginning at the first return of consciousness. Bicycle exercises should also be carried out every three hours, day and night, as soon as feasible in the following types of cases: the obese, patients with varicose veins, cardiac complications, in the elderly and arteriosclerotic and in those with a previous history of thrombophlebitis.

3 *Treatment of Varicosities* Ace bandages are applied in cases of varicose veins to obliterate the stagnant veins.

4 *Application of Heat* A cradle of lamps is put over the lower limbs to hasten circulation by means of heat in patients considered susceptible to venous thrombosis.

The following measures will aid in the early discovery of thrombophlebitis and by the early institution of anticoagulation therapy, prevent pulmonary embolism.

1 *Daily Physical Examination* Daily inspection of the legs for tenderness in the feet, in the calf or groin, and elicitation of Homans' sign (pain in the calf on dorsiflexion of the foot). It must be emphasized that one must not be content to rely on the patient to report calf tenderness. She too often thinks it inconsequential or even that it might

delay her getting up. Time and again the patient has reported to us on later questioning after a benign pulmonary embolism, "Oh, yes, I noticed two or three days ago that my calf was sore but I didn't think it worth mentioning. Sometimes, of course, all measures are futile and we have seen thrombophlebitis develop in three cases after the patient was up and ambulatory.

2 *Temperature Elevation* The temperature and pulse charts should be watched. An unexplained low postoperative intermittent fever, especially occurring after pelvic operations, is to be regarded as an indication of thrombophlebitis until proved otherwise. We feel so strongly on this point that we give dicoumarol anticoagulation therapy on this evidence alone until the patient is safely ambulatory.

#### DIAGNOSIS OF THROMBOPHLEBITIS

There are two types of thrombophlebitis, *phlegmasia alba dolens* or 'milk leg' and the much more dangerous variety from the point of view of pulmonary embolism, phlebothrombosis of the deep calf venous plexus. These two often merge with each other. The first type, once it is well established with swollen, white leg, never throws off an embolism, but it should be remembered that other unrecognized areas of phlebothrombosis in the contralateral leg or in pelvic veins may coexist and throw off emboli.

The second type, phlebothrombosis of the calf, is extremely dangerous, although the signs may be so minimal as to be disregarded by the physician as inconsequential. Therein may lie a fatal mistake. The temperature chart, calf tenderness, and Homans' sign have already been mentioned. We never disregard the most trivial tenderness in the calf because so often fatal pulmonary embolism occurs without warning or, if benign, the signs of phlebothrombosis appear two or three days after the embolism. This is so even if Homans' sign is negative and no fever exists as yet. With embolism there often is a combination of pleuritic chest pain, or sometimes only a sudden sense of suffocation without pain, with mild transitory leg pain. We regard such leg pain as caused by phlebothrombosis until proved otherwise and anticoagulation therapy is instituted immediately. This is one of the advantages of anticoagulation treatment over femoral ligation, because such trivial signs make one hesitate to take recourse to the more radical surgical procedure.

#### TREATMENT

The method of anticoagulation therapy as practiced at the Lahey Clinic is given in detail in the Lahey Clinic number of *Surgical Clinics of North America* for 1944. Briefly outlined, at the first suspicion of

thrombophlebitis, heparin is given intravenously, 2 cc every four hours, or by constant drip in doses large enough to maintain the coagulation time around forty minutes. Dicoumarol is also given at the start in an initial dose of 300 mg to a patient over 150 pounds, 200 mg otherwise, followed by a daily maintenance dose of 100 mg. When the prothrombin percentage has reached 70 to 79, generally on the third day, heparin is stopped. Dicoumarol is continued until the prothrombin percentage is in the 60's. Then only occasional daily doses of 100 mg are given if the prothrombin percentage shows a tendency to climb into the 70's or 80's. We hesitate to push the prothrombin time below 60 per cent, believing lower levels dangerous and unnecessary. When the prothrombin percentage is between 60 and 70, and if the patient's surgical condition permits, she is allowed to sit up. Most patients are up and about within two weeks of their initial vascular accident.

#### RESULTS

In the 381 pelvic operations performed in 1944 and reviewed here, there were no immediately fatal pulmonary emboli (a glowing reflection on the nursing care at the New England Baptist and Deaconess Hospitals). There were only seven cases of thrombophlebitic complications (1.8 per cent), of these, two were classified as thrombophlebitis (*phlegmasia alba dolens*) and five phlebothrombosis with benign pulmonary embolism. There were no fatalities and no recurrent episodes of venous thrombosis or pulmonary embolism under anticoagulation therapy.

In three years approximately 200 patients with postoperative thrombophlebitis and phlebothrombosis with or without benign pulmonary embolism have been treated by dicoumarol anticoagulation therapy at the Lahey Clinic. Continuous intravenous administration of heparin was also used in most cases. Ideally, one should separate the cases of the more dangerous phlebothrombosis from those of the rarely metastasizing thrombophlebitis (*phlegmasia alba dolens*), but this is impractical because the two varieties so often are concurrent. There have been no cases of fatal recurrent pulmonary emboli, and only three cases of benign recurrent pulmonary emboli. In only one of these three cases was there recurrent pulmonary embolism when an adequate prothrombin time had been reached (54 per cent). In one of the other two, treatment had been suspended too soon and a blood transfusion given, in the third the patient had gone home only to return two weeks later with a second benign embolism and in desperate condition. He was given more anticoagulation therapy after bilateral ligation of the femoral vein was performed.



## ILLUSTRATIVE CASE REPORTS

Three cases are cited to illustrate the problems of thrombophlebitis in gynecologic practice

**CASE I**—A woman, aged thirty seven years, was admitted to the hospital October 18, 1944. The diagnosis was primary dysmenorrhea, corpus hemorrhagica of the left ovary and rectocele. She gave a past history of postpartum thrombophlebitis in 1936 with swollen right leg ever since. Bilateral varicose veins were present.

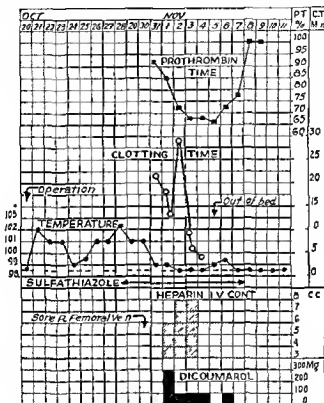


Fig. 773 (Case I)—Salpingo oophorectomy. Postoperative femoral thrombophlebitis treated by heparin and dicoumarol.

October 20, 1944, the following surgical procedures were performed: dilatation and curettage, cervical cauterization, perineorrhaphy, appendectomy, and left salpingo-oophorectomy.

**Postoperative Course** The patient ran a febrile course from the first day, with the temperature as high as 102°. There were 30 to 50 white blood cells present in a catheterized specimen of urine, and sulfathiazole was administered for suspected pyelocystitis. Because of the past history of thrombophlebitis and the presence of varicose veins, she

was watched carefully for signs of thrombophlebitis. On the tenth postoperative day soreness appeared in the right groin and tenderness was present over the course of the right femoral vein. No further confirmatory signs, such as swelling of the leg, sore calf, or positive Homans' sign, were waited for. Anticoagulation therapy was immediately started (Fig. 273). There was prompt fall of temperature, which suggested that the previous fever which was uninfluenced by four days of sulfonamide therapy may have been the result of thrombophlebitis rather than of a urinary infection. No swelling developed. The soreness in the right femoral region disappeared in four days. She was allowed up without untoward incident on the sixth day of treatment when the prothrombin time was 66 per cent. Dicoumarol was stopped on the eighth day because temperature and pulse rate were normal. Three days later the prothrombin time reached normal.

*Comment*—This case illustrates a suspicious background of previous postpartum thrombophlebitis and varicose veins. If there is a previous history of thrombophlebitis, the likelihood of occurrence of postoperative pulmonary embolism is tripled. Three principles of prophylaxis were overlooked in this patient: elastic compression of the varicose veins, prophylactic treatment with dicoumarol because of the past history of thrombophlebitis, and dicoumarol administration because of inadequately explained postoperative fever. It must be said in extenuation that this patient was most carefully watched for the first signs of thrombophlebitis and that the postoperative fever may have been caused by pyelocystitis, as thought at the time.

**CASE II**—A woman, aged fifty years, was submitted to right hemithyroidectomy January 2, 1944, for a nontoxic thyroid adenoma. She also suffered from urethrocele, cystocele, rectocele and fibroid uterus. On January 11 the following procedures were carried out: dilatation and curettage, anterior colporrhaphy, perineorrhaphy, supravaginal hysterectomy, bilateral salpingo-oophorectomy, and appendectomy. On January 21 she complained of sudden pleuritic pain and coughed up blood. A positive Homans' sign and tenderness in the left calf were present. Physical examination of the lungs was negative. A roentgenogram of the chest revealed an elevated left diaphragm, but the lung fields were clear. A diagnosis was made of left calf phlebothrombosis with pulmonary embolism, and treatment with heparin and dicoumarol was started immediately (Fig. 274).

*Comment*—This case illustrates the simultaneous discovery of benign pulmonary embolism and the trivial symptoms of dangerous calf phlebothrombosis. The efficient and prompt prevention of further

venous thrombosis and recurrent phlebothrombosis is suggested (Only statistical studies in a large number of cases prove further thrombotic accidents are prevented by any method of treatment )

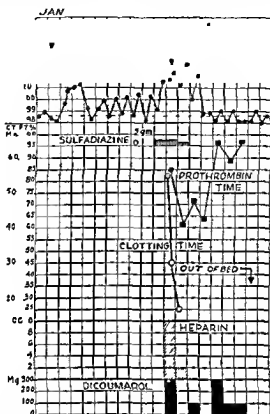


Fig 274 (Case II) Hysterectomy Postoperative calf phlebothrombosis with benign pulmonary embolism Treatment by heparin and dicoumarol

CASE III—A woman, aged fifty years had a fibroid uterus removed on July 21, 1944, by supracervical hysterectomy, bilateral salpingo-oophorectomy was also performed. Nine days later she suffered an acute right pleuritic pain, but the chest examination was negative. Within two days physical and roentgenologic signs of consolidation developed at the right base. Roentgenography also revealed mottling in the left lung, suggesting an "embolic shower." Not until six days after the initial pleuritic pain did this patient reveal any signs in her legs, namely tenderness over the left femoral vein, a positive Homans sign, and within two more days swelling of the leg. By this time all the signs of phlegmasia alba dolens of the left leg were present.

Dicoumarol (Fig 275) was administered when the leg began to swell and the true condition was recognized. Because this patient had

a swollen leg indicating venous stasis and reflex arterial spasm, left paravertebral sympathetic procaine block was carried out on two occasions

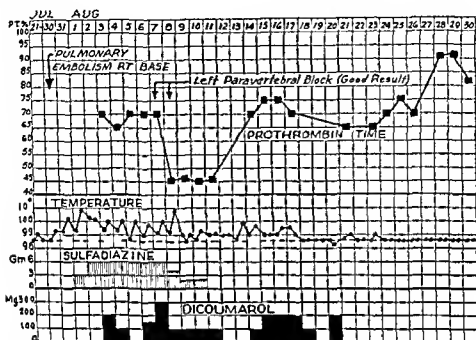


Fig 77 (Case III) —Hysterectomy Postoperative benign pulmonary embolism followed by phlegmasia alba dolens Treatment by paravertebral sympathetic procaine blocks and dicoumarol

*Comment*—There was prompt control or reduction of fever in all three of these cases on institution of anticoagulation therapy. In Case III no signs of thrombophlebitis developed until long after the pulmonary embolism. Signs of calf phlebothrombosis soon merged into full blown femoral thrombophlebitis or phlegmasia alba dolens (old fashioned milk leg). Pulmonary emboli come from fresh, usually unrecognizable areas of phlebothrombosis, hence their unpredictable danger. The value of anticoagulation therapy lies in its prevention of new dangerous foci of phlebothrombosis from which recurrent pulmonary emboli may spring.

Case III also illustrates the use of sympathetic blocks to combat the edema of venous stasis.

#### SUMMARY AND CONCLUSIONS

Prophylactic measures to prevent postoperative thrombophlebitis and pulmonary embolism are effective as illustrated by the low incidence (seven cases or 1.8 per cent) of such accidents in 381 major pelvic gynecologic operations in 1944. Five of these seven patients had

benign pulmonary emboli. Fortunately, there were no cases of sudden fatal pulmonary emboli. All seven patients were treated by anticoagulation therapy without further recurrence of either thrombophlebitis or pulmonary embolism. This method of treatment has, in our experience, largely eliminated the necessity of femoral ligation and has shortened convalescence to a period usually within two weeks of the initial thrombotic incident.

## SYMPOSIUM ON THYROID SURGERY

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### INTRATHORACIC GOITERS

FRANK H. LAHEY

THE subject of intrathoracic goiter has interested me for a great many years. In fact, the first paper I ever read before the Surgical Section of the American Medical Association was on this subject in New Orleans in April 1920.<sup>1</sup>

#### DEFINITION

A great many writers on this subject have urged the importance of establishing a dividing line between what is truly an intrathoracic goiter and what is truly short of one. There will always be the inclination to speak of any goiter which extends downward into the superior mediastinum, even though the extending tongue of thyroid tissue be only a few inches into the mediastinum, as intrathoracic goiter. If we wish to avoid confusion in these two conditions in terms of seriousness, mortality, technical and anesthetic difficulties, operative and postoperative complications, symptomatology and diagnosis, we must restrict the term intrathoracic goiter to those cases in which, for practical purposes, the entire goiter is within the chest, to those cases in which the greatest diameter of the intrathoracic mass by roentgenogram is well below the upper aperture of the thoracic cage made by the sternum, first ribs and vertebral bodies. We must restrict this diagnosis to those cases in which the thyroid has descended so far into the thoracic cage and has become so widened in its diameter that it is at no time able to escape upward from its deep position in the mediastinum because the diameter has reached such proportion that it can no longer pass through the upper thoracic aperture.

#### ORIGIN

In writing on this subject I have frequently discussed the mechanics of how a goiter becomes intrathoracic. To understand how this occurs it must be stated that all intrathoracic goiters start either as discrete adenomas of the thyroid or as multiple adenomatous goiters and that they are originally located at the normal level of the thyroid and gradually descend from that position to the point in the mediastinum which they ultimately reach when they become true intrathoracic

goiters. It has been repeatedly stated in the literature that just as thyroid remnants remain behind in the normal descent of the thyroid to produce lingual or sublingual undescended thyroids so does thyroid tissue descend into the mediastinum abnormally beyond its true position on the upper tracheal rings to be the origin of intrathoracic goiter. I do not believe that this can be true or if so it must be extremely rare since in my experience now with operations on 24,000 patients with goiter I have never been able to verify it.



Fig. 276.—This is the deep spherical type of intrathoracic goiter, a discrete adenoma, as shown by the extreme distortion of the course of the trachea indicated by dots.

To realize how the thyroid becomes intrathoracic one must appreciate the anatomy at the root of the neck. The fascia planes between which the thyroid rests. The thyroid gland is situated in front of the prevertebral fascia and behind the pretracheal fascia. This places it in a fascia plane which enters directly into the superior mediastinum. It is a space with no bottom and with adenomas existing in the thyroid there is always a tendency as the neck is flexed for the adenoma to be crowded downward as the patient swallows and the adenoma ascends.

and descends. When an adenoma is small, it undoubtedly passes into the mediastinum and, with swallowing and extension of the neck, may partly pass out of the mediastinum, but as the adenoma eventually becomes larger in its position within the mediastinum there comes a time when it no longer, either by swallowing, coughing or violent effort, can pass out of the mediastinum upward into its position on the neck.



Fig 277—This is the nonspherical, tongue-like projection into the mediastinum. Note the deviation and narrowing of the trachea as indicated by two arrows, and the depth of the intrathoracic extension, the right outline of which is marked by *x* and its relation to the arch of the aorta marked *a*.

The origin, therefore, of intrathoracic goiter is an adenoma arising usually in the isthmus or either lower pole of the thyroid and eventually descending along the course of least resistance, that is downward between the fascia planes into the mediastinum.

There are two types of intrathoracic goiter, the large spherical type as shown in Figure 276, and the long tongue of intrathoracic goiter which frequently runs down beside the trachea deeply into the mediastinum (Fig. 277).



## DIFFERENTIAL DIAGNOSIS

The differential diagnosis of intrathoracic goiter is interesting and not extremely difficult. Most spherical tumors of tongue like masses running down beside the trachea into the superior mediastinum that ascend and descend with swallowing are intrathoracic goiters. Any tumor of this type the upper limits of which can readily be palpated and which ascends and descends with swallowing is more likely to be an intrathoracic goiter than anything else.



Fig. 278 In this is shown the effect of an intrathoracic fibroma of the esophagus upon the esophagus itself filled with barium. This phenomenon has never been seen in our experience with an intrathoracic goiter.

The tumor which can be most readily confused with it of which we have had three examples is a *fibroma arising in the esophageal wall*. These are spherical in outline, firm in character, ascend and descend with swallowing, are at times partly in the mediastinum and partly out, and at other times are completely in the mediastinum. One can frequently feel the top of these tumors and by roentgenologic examination they present a shadow very similar to that presented by an intrathoracic goiter. There is one distinguishing factor and that is

when the patient is given a thin barium meal, a distinct indentation of the esophagus can be seen since these tumors arise in the wall, usually project partly inward, and so produce a smooth spherical indentation in the roentgenographic shadow of the barium filled esophagus. It is rare for an intrathoracic goiter to produce any pressure change upon the esophagus, this is, therefore, a valuable distinguishing feature between intrathoracic goiter and fibroma of the esophagus (Fig. 278)



Fig. 279—In this illustration is shown the effect of an adenoma arising in the isthmus producing anteroposterior pressure and anteroposterior narrowing of the trachea. The caliber of the trachea above the narrow point is shown between arrows the most marked point of narrowing is indicated just above the sternal notch by an arrow and the caliber of the trachea where it is not compressed within the mediastinum is shown by the lower arrow.

So great is the similarity between fibroma arising in the esophageal wall and an intrathoracic goiter that one may even be in doubt with the neck open and the upper pole of the intrathoracic tumor visible on swallowing in the upper part of the mediastinum. I have written in various discussions of fibroma of the esophagus that one can always differentiate intrathoracic goiter anatomically with the neck open by the position of the inferior thyroid artery and the recurrent laryngeal

nerve. These structures in intrathoracic goiter are always posterior to the tumor mass since the thyroid is anatomically placed over the trachea and forward of these two structures, while in fibromas of the esophagus, intrathoracic in location as they usually are, the inferior thyroid artery passes over the front of the tumor as does the recurrent laryngeal nerve, since the esophagus is located posterior to both of these structures. These anatomical relationships of the inferior thyroid artery and the recurrent laryngeal nerve have been of value to me at operation in quickly distinguishing these two types of intrathoracic tumors.

The effect of intrathoracic goiter by pressure on the trachea is quite constant. Most intrathoracic goiters are located in either the right or the left lobe, and because of this tend to push the trachea to the opposite side from that on which they are located. This produces characteristic curving as shown in Figure 276, and characteristic narrowing from the lateral pressure, as shown in Figure 277.

In a few cases an adenoma arising in the isthmus will descend behind the manubrium and produce anteroposterior pressure upon the trachea as shown in Figure 279. In addition to that, not infrequently the adenomas which arise in the isthmus, remain in the midline and descend behind the sternum, will produce choking as the patient bends forward, due to the increased anteroposterior pressure which goes with acute flexion of the neck upon the chest.

*Neurofibromas, dermoid cysts, fibromas and pleural cysts*, occurring occasionally as they do in the upper mediastinum, must be distinguished from intrathoracic goiter. They do not ascend and descend with swallowing, they are rarely palpable through the upper thoracic strait, they do not tend to deviate the trachea as do the intrathoracic goiters due to the fact that they arise within the chest cavity and are not anchored as are intrathoracic goiters to the thyroid above. Thus it is possible for them unanchored as they are to migrate outward if they enlarge and they do not cause tracheal pressure and deviation.

*Lymphosarcomas and secondary carcinomas* particularly of the stomach, extending upward along the thoracic duct, should almost never be confused with intrathoracic goiter. Lymphosarcomas are broad of base, without discreteness in outline and usually fixed. As is the case with metastases, metastatic extensions occur along the thoracic duct to eventually be demonstrable as a Virchow's gland behind the left sternomastoid muscle. This type of malignant extension is fixed, does not ascend and descend, is a shadow without discreteness in outline and is not easily confused with an intrathoracic goiter.

## ROENTGEN STUDY

One should not fail to take roentgenograms of the upper mediastinum in any patient with an adenomatous goiter which tends to extend beneath the clavicle or beneath the sternum. In an experience now with over 24,000 goiters we have regretted the omission of this diagnostic feature several times. We have found intrathoracic extensions which were not suspected when the patient was originally seen, and could easily have been overlooked and left behind, and the patient return later with much larger intrathoracic goiter. We have always instructed our assistants that whenever an adenomatous goiter is low lying, that patient should have a roentgenogram of the upper mediastinum, and it is surprising how many times unsuspected intrathoracic extensions have been demonstrated.

## PHYSICAL SIGNS

One does well to remember that intrathoracic goiters are to be diagnosed not only from the above described evidence but also from direct evidence. Rarely do intrathoracic goiters exist in any considerable size without producing pressure upon the internal jugular vein, interfering with return of blood supply from the head and causing *dilatation of the superficial thoracic veins* over the chest. These veins tend to be dilated particularly on the side on which intrathoracic goiter exists, which causes us always in adenomatous goiter to suspect the possible presence of an intrathoracic goiter.

Large intrathoracic goiters not infrequently cause extensive pressure on both internal jugular veins and in advanced cases can produce marked *engorgement of the neck veins* and in very advanced cases *edema of the face*.

Well developed intrathoracic goiters can be readily detected by percussion, a method of physical examination which should never be omitted in any patient with the low lying adenomatous type of goiter.

*Deviation of the larynx* in intrathoracic goiter, particularly if partly extrathoracic, is also a physical sign which is often overlooked in the diagnosis of intrathoracic goiter. If one will mark with ink the mid point of the chin and the midpoint of the sternal notch, then the position of the thyroid cartilage in relation to these two points it will often demonstrate that the laryngeal cartilage is off center, having been so pushed to one side by an intrathoracic extension that this deviation of all of the trachea, larynx and thyroid cartilage has taken place. More than once this has proved a valuable physical sign to me in patients suspected of having intrathoracic goiters.

We have seen so many patients with intrathoracic goiters that we

can almost make the diagnosis in the true intrathoracic goiters from the characteristic *cough* that frequently goes with them. Due to the fact that the trachea is so frequently narrowed by lateral pressure these patients have a typical stridor on inspiration of vigorous character, brought about by the whistling of the air as it passes through the narrowed trachea. They also have a typical raspy type of cough brought about likewise by the rapid expulsion of air with cough as it passes outward through the narrowed aperture made by the compressed trachea.

These above mentioned physical signs have been of great value to us, causing us to be suspicious of the diagnosis of intrathoracic goiter in those patients with low lying adenomas of the thyroid or adenomatous type of goiter.

We have in general taken the position that intrathoracic goiter should not exist and that any patient who has a low lying adenoma or a low lying adenomatous goiter tending to become substernal should have it removed before it descends into the position here described.

#### PRINCIPLES OF REMOVAL

I have elsewhere in the literature published articles on the technical procedures and methods to be employed in the removal of intrathoracic goiter. I do not wish in this article to enter into the discussion of their removal but wish only to mention a few of the fundamental requirements in any operative procedure.

True intrathoracic goiters have frequently so almost completely obstructed the trachea that the addition of a general anesthetic such as ethylene, cyclopropane, nitrous oxide or ether, with the engorgement and promotion of mucus and secretions which go with general anesthetics will not infrequently serve to produce complete tracheal obstruction. Therefore, one of the essential features of any successful operation for a true intrathoracic goiter is, as a first step, the introduction of a rigid wall, semirigid, metal intrathoracic tube. This can be done in the advanced cases under topical anesthesia, and makes possible all degrees of manipulation of the tumor without tracheal obstruction as it is extracted from its position within the mediastinum. Without this, the operation will often be hurried the emergency alarming, particularly as the tumor is pulled out of the chest, and the trachea without a tube in place is collapsed by the resulting pressure and bleeding caused by the necessary haste is often disturbing. The dangers of mortality and morbidity under these unnecessarily trying circumstances are obviously increased.

We have removed intrathoracic goiters that have extended nearly

to the diaphragm. Tumors, as shown in Figure 280, can be removed from the mediastinum which are obviously of too great diameter to pass through the upper thoracic strait. This is accomplished by incising the tumor at its upper pole after its blood supply from above, the two superior and inferior arteries, has been ligated, breaking down its center, sucking out its semiliquid contents until it is gradually so decreased in diameter that it can be extracted. This measure has proven



Fig. 280—In this illustration it can be seen that the diameter of this intrathoracic tumor is so great that it could not possibly pass through the opening between the vertebral bodies and the sternum, clavicle and first rib. But two measures can be applied to make its delivery possible: one to enlarge the opening in the chest and the other to decrease the size of the tumor. A method to accomplish the latter is described in this paper.

of the very greatest value to us in the removal of large intrathoracic goiters as without it they could be removed only by resection of the chest wall, sternum and clavicle, shocking procedures which with this plan are unnecessary.

Finally, as a fundamental measure in the treatment of intrathoracic goiter we have learned that following their removal the cavity left in the mediastinum must be loosely packed with gauze to control the

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## CONTROL OF BLEEDING IN THYROIDECTOMY AND CONDITIONS PREDISPOSED TO INCREASED BLEEDING

LARI J BOEHM

THE technic of subtotal thyroidectomy as practiced in this Clinic places particular emphasis on the control of bleeding. This is necessary since the vascular supply of the thyroid gland is greater than that of almost any other structure approached surgically. The careful ligation of all significant vessels actually reduces the total operating time and gives a greater insurance against postoperative hemorrhage. The lateral dissection, necessary for the ligation of the lateral veins and the inferior thyroid artery, and the exposure of the recurrent laryngeal nerve, which is done in every thyroidectomy, make possible a more accurate estimation of the size of the thyroid remnants and give one the opportunity to see and preserve the parathyroids.

That part of the thyroidectomy technic concerned with hemostasis must begin with observation of the patient while the anesthesia is being induced. The external jugular veins will be distended, thus revealing their exact locations. With safety the incision in the skin may then be extended laterally to the veins when necessary. When raising the skin flap the plane of dissection should be kept in the areolar tissue of the deep cervical fascia, thus exposing the anterior jugular veins and the communicating veins between the anterior jugular and common facial veins. When there is massive distention of these veins they may be encircled with one suture ligature at the upper and lower end of each trunk before they are clamped across and cut in the routine division of the ribbon muscles.

After division of the ribbon muscles the upper pole of the gland is grasped with a double hook and retracted medially. The visceral fascia of the gland is separated at the lateral border between the gland and the lateral border of the sternothyroid muscle. Careful dissection in this plane of cleavage will expose the middle thyroid vein. Here one finds not an easily recognizable distended vein (Fig. 281), but a thin, pale friable vessel emptied because of traction on the lobe. It must be carefully divided between hemostats and ligated. The distal end empties directly into the internal jugular and, if not controlled, quickly stains the area with blood, making the important deep lateral dissection more difficult. If a superior thyroid vein empties laterally and below



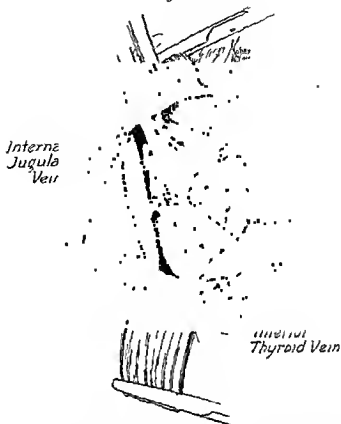


Fig 281—Division of lateral thyroid vein Visceral fascia carefully dissected to expose vein (From Lahey, F H Technique of Thyroidectomy Surgery, 16 707, 1944)



Fig 282—Note finger in lateral gutter pushes superior pole forward when ligating superior pole vessels Thus injury to the recurrent nerve is avoided at this high level

the apex of the upper pole it should be ligated in the same fashion before isolation and ligation of the superior thyroid vessels.

After careful dissection of the superior pole, a finger placed against the inferior horn of the thyroid cartilage is used to push the pole anteriorly as the ligature is passed about the vessels since above the edge of the easily palpable cartilage the recurrent laryngeal nerve is intralaryngeal and is not in danger of injury (Fig 282). The vessels should either be doubly ligated at this time or, after ligation and removal of the lobe, the cut ends of the vessels should be regrasped and ligated.

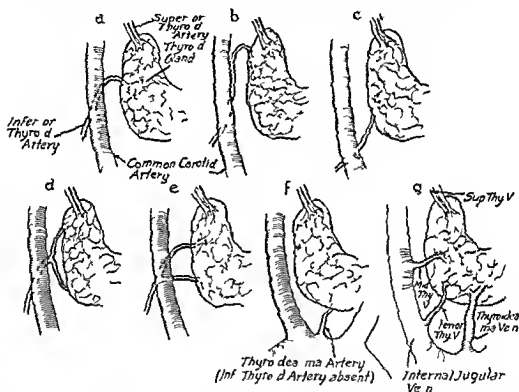


Fig 283—The variations in the course of the inferior thyroid artery. *a* and *d* are the most commonly observed positions of the vessel. (From Lahey F H. *Technique of Thyroidectomy Surgery*. 16711. 1944.)

once more. This will insure against postoperative hemorrhage from coughing or straining.

The inferior thyroid artery should always be ligated since it is usually a larger vessel than the superior. Until recently the standard anatomy textbook portrayed the inferior thyroid artery coming from below and entering the lower pole of the gland. This is actually the least common position of the vessel. Although its location may vary (Fig 283), it usually arches upward from the thyrocervical trunk and coming from behind the carotid sheath enters the side of the gland often in a downward direction (Fig 284). The vessel is usually ligated

in continuity and not divided. Care must be taken to search the lateral gutter for a second vessel since the main trunk may have divided behind the carotid sheath, and the overlooked branch will be the source of brisk bleeding when the gland is resected. If the inferior thyroid artery cannot be found readily, it may be that it is actually absent or that it enters very low on the gland.

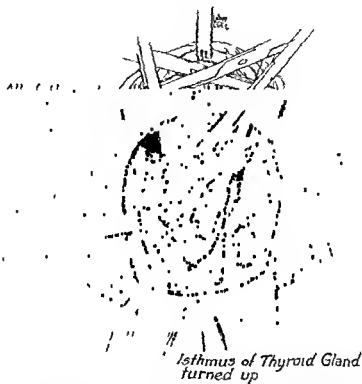


Fig. 284.—The inferior thyroid artery in its usual position, ligated in continuity. Retraction of the carotid aids in locating the inferior thyroid artery (From Lahey, F. H. *Technique of Thyroidectomy Surgery*, 16710, 1944.)

Dissection and ligation of the inferior thyroid artery is intimately associated with exposure of the recurrent laryngeal nerve. Ligation of the vessel should not be done until the course of the nerve is accurately demonstrated. The nerve commonly passes behind the branches of the artery but may pass between or in front of them. Often the preliminary dissection and exposure of the nerve is the easiest method of demonstrating the presence or absence of the artery. The nerve is frequently in an anomalous position in intrathoracic goiter, but the artery is little disturbed.

At the lower pole the inferior thyroid veins are encountered. These

must be ligated individually. Cut ends retract beneath the sternum if not carefully controlled. The thyroidea ima vein can be said to exist only when the plexus of inferior veins or the right and left inferior veins unite to form a single trunk which opens into the innominate vein. This will usually be directly over the trachea.

The thyroidea ima artery is present in about 10 per cent of patients. It may arise from the innominate artery, but can come from the arch of the aorta or the right common carotid artery. It ascends in front of the trachea, and it should be ligated and divided to allow for the removal of the isthmus of the gland from the trachea.

After ligation of these principal vessels and resection of the gland there will be moderate oozing from the cut surface of the lobe remnants. This bleeding is from the small anastomotic branches from the larynx and the trachea. This is controlled by suture of the lower two-thirds of the remnant to the side of the trachea and suture of the upper third of the remnant to the fascia and fibers of the thyrohyoid and cricothyroid muscles. If there is brisk arterial bleeding, it may originate from an overlooked branch of the inferior thyroid or from an unligated posterior glandular or medial branch of the superior thyroid. Either of the latter may leave the main trunk above the point of ligation.

#### CONDITIONS ASSOCIATED WITH INCREASED BLEEDING

In a large experience with thyroidectomy, and recalling moments of dismay in the past, one becomes familiar with certain types of goiter or associated conditions that increase the technical difficulty of hemostasis. By adhering to a fundamental anatomical approach and recognizing these conditions one need not jeopardize the result nor increase the mortality rate. Most of the more difficult cases may be anticipated before operation. Much reliance must be placed on the knowledge and skill of the anesthetist and the internist. The difficulties related to increased bleeding are either physiologic or anatomical or both. Grouped together they are as follows:

- 1 Subinvolution of hyperplastic thyroids
- 2 Toxic patients prepared with thiouracil alone rather than thiouracil plus iodine
- 3 Hypertension
- 4 Rise in blood pressure associated with anesthesia
- 5 Hemorrhagic tendency
- 6 Substernal and intrathoracic goiter
- 7 Thyroiditis and struma lymphomatosa
- 8 Malignancy
- 9 Congenital goiter

*Subinvolution* as a cause of increased bleeding is no longer an important factor since the severely toxic patients are now prepared for operation with thiouracil plus iodine the latter given the final three weeks before operation. It is true that in preparing a mildly or moderately toxic patient with iodine alone for ten to fourteen days, one probably does not obtain the maximum degree of operability. One must then accept some increased bleeding from the gland and the tendency to higher blood pressure during the operation however in this type of patient there is very little added risk.

In patients prepared with *thiouracil alone* such a marked hyperplasia of the gland develops that control of bleeding becomes a major problem in the procedure. Fortunately this preoperative preparation has now been augmented by the iodine given two to three weeks before operation. The gland is then found to be so completely involuted that the problem of hemostasis is almost nonexistent.

Patients with *hypertension* require meticulous hemostasis since with heavy preoperative sedation they may come to operation with lowered blood pressure. After operation the pressure rises and this plus coughing and straining may initiate serious postoperative hemorrhage. Most of these cases of true hypertension are associated with nodular goiter and these patients average ten to twenty years older than patients with primary hyperthyroidism.

*Rise in blood pressure associated with anesthesia* occurs both during induction and during hypoxia or carbon dioxide retention or both. The rise during induction is most marked in toxic patients. A further rise usually occurs after the operation is started. An increase in bleeding from the skin flap and other cut surfaces during the operation may indicate a rise in blood pressure resulting from oxygen deficiency. This may be caused by laryngeal spasm or other obstruction in breathing. Carbon dioxide retention has the same effect on the blood pressure with resultant increased bleeding. These are conditions that can be controlled and corrected by the anesthetist.

Patients with *hemorrhagic tendencies* are not always easy to detect before operation. They may give a history of bruising easily or of prolonged bleeding after tooth extraction. Usually the first indication is found at operation. These disturbances in the bleeding time and/or clotting mechanism may be mildly troublesome or may be severe as in cases of pseudohemophilia. Operation on toxic patients should not be deferred because of known bleeding tendency. A sixteen year old boy with a moderate primary hyperthyroidism exhibited such profuse bleeding at operation that it was necessary to do the thyroidectomy.

in two stages. Recovery was uneventful and the disease of the thyroid was eliminated successfully.

*Substernal and intrathoracic goiters* interfere with the venous return through the superior strait of the thorax. The veins of the neck are usually massively dilated. On elevating the ribbon muscles from the gland the venous plexus of the thyroid will exhibit marked distention. If not diagnosed by clinical examination or roentgenologic examina-



Fig. 285.—Congenital goiter prominent since birth in a male aged twenty-one years. Arrows indicate large visible superior thyroid arteries.

tion of the trachea before operation, such a picture must immediately suggest to the surgeon the presence of substernal extensions of the gland. Elevation of the lobes must be undertaken with great care to avoid pulling off the friable veins. If possible, both the superior and inferior thyroid vessels should be ligated before delivery of the gland; however, the inferior thyroid artery is usually inaccessible until the gland is elevated out of the superior strait and retracted medially.

*Thyroiditis* and *Hashimoto's disease* cause increased bleeding chiefly because dissection is difficult. Cleavage planes are obliterated and separation of the ribbon muscles from the gland is difficult and often bloody. The glands are not abnormally large and technically are not otherwise difficult to handle except for occasional difficulty in isolating the adherent lateral veins.

In *malignancy* there is increased cellular and vascular proliferation. The normal anatomical structure of the gland is altered. Tissue cleavage planes may be destroyed by invasion of the muscles, the trachea and venous channels. Dissection is then difficult and necessarily sanguinous. Confronted with such a situation one should immediately perform a biopsy and examine a frozen section to confirm the diagnosis. Transfusion will be necessary if radical resection of gland and adjacent structures is necessary.

*Congenital goiter*, particularly of the adenomatous type, differs from the acquired types in that its vascularization is intensely developed. The venous plexuses of the gland are greatly increased in size and in number. The arteries likewise become enlarged and prominent. An example of this striking vascularity is the twenty one year old male (Fig. 285) whose pulsations of the superior thyroid arteries were easily visible in his neck. At operation these and the inferior thyroid arteries were found to be nearly equal in size to the carotid at that level. There were numerous lateral and inferior thyroid veins, many of which distended to the size of the index finger. Painstaking ligation and division of these veins is essential since rough handling or attempts to elevate the large gland prematurely will precipitate hemorrhage of serious proportion should even one of the veins be torn. The arteries should be doubly ligated with suture ligatures of heavy silk.

## ANESTHESIA FOR THYROID SURGERY

MORRIS J NICHOLSON

GENERAL anesthesia is our choice for almost all thyroid operations because it fulfills the average patient's desire to be asleep and is relatively nontoxic.<sup>2,3</sup> In addition, it gives the surgeon the perfect freedom he needs to accomplish the wide lateral exposure so essential for the radical removal of the thyroid gland without injury to the recurrent laryngeal nerves or parathyroid glands. The carbon dioxide method of administration is usually employed for these thyroid operations, with endotracheal intubation as indicated.

Two factors make anesthesia for thyroid operations different from most other types of anesthesia. They are the toxicity of the patient and the possibility of respiratory obstruction occurring during the operation.

The subject of anesthesia for thyroid surgery can best be discussed under the following headings: toxicity of the patient, mechanical interference with the airway, premedication, selection of the anesthetic agent and management of complications, operative and postoperative.

### TOXICITY

Hyperthyroidism is a disease that affects the entire body, but the liver,<sup>3</sup> gastrointestinal tract,<sup>4</sup> cardiovascular<sup>16, 17</sup> and central nervous systems seem to be most vulnerable. Evidence of this vulnerability is found in the patient's complaints of nervousness, irritability, emotional instability, weight loss, weakness, fatigue, increased appetite, intolerance to heat, dyspnea, palpitation, vomiting and diarrhea.

If postoperative reaction, crisis and death are to be prevented, an attempt must be made during the period of preoperative preparation to rectify these complaints. This can usually be done by bed rest, sedation, a diet high in carbohydrate, protein and vitamin content, plus iodine or thiouracil medication as indicated. On this regimen most thyrotoxic patients will gain weight and show a decrease in pulse rate. As their basal metabolic rate decreases and their nervousness subsides there often is improved liver function.<sup>3</sup> However, a long clinical experience has proved the following factors to be of unfavorable prognostic significance: age of fifty years or over, duration of disease more than one year, loss of one fifth or more of the body weight, failure to gain weight during the preoperative period of rest and medication, failure of the pulse rate to drop to 100 or below during prepara-



tion, persistent auricular fibrillation or a history of previous cardiac failure, high initial basal metabolic rate and failure of the rate to drop sufficiently under treatment, and failure of preanesthetic medication to produce the usual sedation. These danger signs may be found in any patient suffering from primary hyperthyroidism and should be readily appreciated.

The risk presented by patients suffering from the apathetic type of thyrotoxicosis is not so generally recognized.<sup>13</sup> Most of these patients are elderly, have had the disease a long time, and have lost much weight. Many of the signs of thyroid toxicity have long since become masked. The patients appear to be calm, the pulse rate may be slow, and the basal metabolic rate only slightly elevated. Unless this masked toxicity is recognized and a careful regimen of bed rest, sedation, high caloric, high vitamin intake plus iodine or thiouracil medication is instituted, thyroidectomy may result in waning of strength and life. Death occurs in these patients apparently without any sign of a relighting of the thyroid activity such as that seen in patients with the activated type of hyperthyroidism.

In the case of each seriously ill patient it should be decided before operation whether the entire surgical procedure may be safely done at one time or should be divided into two or more operations. If the latter course is chosen it should be adhered to rigidly, even though the pulse rate, pulse pressure and oxygen consumption during operation indicate a favorable course. It is gratifying to say that since the introduction of thiouracil by Astwood<sup>14</sup> and its clinical supervision at the Lahey Clinic by Bartels,<sup>5</sup> multiple stage operations in cases of severe thyrotoxicosis have shown a striking decrease and now are extremely uncommon.

When thyrotoxic patients are prepared with thiouracil there is a progressive decrease of their toxic signs and symptoms with an accompanying reduction in the basal metabolic rate. It is not unusual for a patient with the classical signs and symptoms of severe hyperthyroidism to come to operation after two months of preparation with thiouracil with a reduction in basal metabolic rate from +65 to -10. Along with this amazing drop in the basal metabolic rate the patient usually shows a gain in weight of 15 or 20 pounds and may even present the signs of hypothyroidism. The clinical recognition of this state of hypometabolism is of real significance to the anesthetist. No longer do these patients require heavy preanesthetic medication, basal narcosis with avertin and heavy postoperative sedation. Rather, after intensive thiouracil preparation they are almost myxedematous and should have light premedication, no basal narcosis, light anesthesia for

their operation and light postoperative sedation. Failure to appreciate fully this great change in the metabolic activity caused by thiouracil can only spell undue depression for patients if the anesthetist considers them in the light of their former toxic state rather than their actual state of hypometabolism. The rather benign anesthetic course of a severely toxic patient prepared for operation with thiouracil is shown in Figure 286.

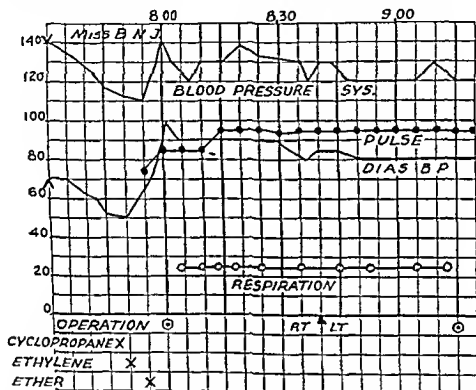


Fig 286—Anesthetic course of a sixteen year old girl who had severe thyrotoxicosis. The initial basal metabolic rate was +66. She received thiouracil 0.2 gm three times a day for thirty days and showed gain of 15 pounds in weight and loss of classical signs and symptoms of thyrotoxicosis with a drop of the metabolic rate to +7. Iodine without thiouracil was given the last twenty-one days of preparation. Note the pulse rate was consistently below 100 beats per minute and the systolic and diastolic blood pressure was within normal limits. Postoperative course was uneventful after one stage subtotal thyroidectomy.

At this time it would seem that the use of thiouracil has more or less revolutionized the anesthetic management of the severely toxic thyroid patient. The indications for multiple stage operations have shown a striking decline. The operative course is seldom fraught with danger, and postoperative reactions, when seen, are seldom severe. However, thiouracil must be used with extreme caution as it has the ability to depress the white blood cell count, particularly the polymorphonuclear

elements to a dangerous and even fatal level. For more complete details the reader is referred to the papers of Bartels and others.<sup>25</sup>

#### MECHANICAL INTERFERENCE WITH THE AIRWAY

The possibility of respiratory obstruction occurring during a thyroid operation is greater than in most other types of operations commonly performed. Manipulation of the trachea during the course of



Fig. 287 Trachea is deviated to the right by a large intrathoracic extension of the left lobe of the thyroid gland.

the operation with the head extended may cause partial or complete respiratory obstruction. A single large adenoma may deviate the trachea acutely from the midline, while a large bilateral adenomatous goiter may compress the trachea in the anteroposterior diameter or narrow it from side to side (Fig. 287). Intrathoracic extensions of the thyroid gland are especially likely to cause obstruction during their extraction.<sup>14</sup> Many carcinomas of the thyroid cause obstruction because of their size, position or even by direct invasion of the trachea (Fig.

288) Acute laryngeal obstruction may occur during or after operation when one or both recurrent laryngeal nerves have been injured, as this results in unilateral or bilateral vocal cord paralysis

Our experience has shown the wisdom of electing the endotracheal method of anesthesia to insure a free airway for those patients with (1) deviated or compressed trachea, (2) recurrent hyperthyroidism,



Fig 288—Trachea is deviated to the left and compressed on its right and posterior aspects by a giant cell carcinoma of the right lobe of the thyroid gland. Note extension of right lobe of thyroid into the mediastinum

(3) cancer of the thyroid, (4) intrathoracic goiter, and (5) unilateral or bilateral paralysis of the vocal cords

Endotracheal intubation may become necessary during the course of the operation when the ordinary adjuncts, such as elevation of the chin, use of oral and nasopharyngeal airways, light positive pressure on the breathing bag, and helium<sup>7</sup> to thin the mixture, all fail to relieve satisfactorily the existing partial obstruction. A patient with a receded



**anesthesia practice** Once the endotracheal tube is in place and the stridor and struggle to breathe have been relieved, these patients frequently fall off to sleep. After the intubation has been accomplished, general anesthesia may be instituted with impunity. Figure 289 shows the steps used in performing endotracheal intubation by the direct method.

On occasion, the use of helium in the presence of severe respiratory obstruction from tumor, edema of the false cords, or vocal cord paralysis has been spectacular in restoring oxygenation and facilitating induction of general anesthesia. Approximately 75 per cent helium and 25 per cent oxygen is administered at the outset, and as the labored breathing is relieved, cyclopropane is added in sufficient amounts to produce general anesthesia. Whenever this situation is encountered, we believe a tracheotomy should be done, and a method of providing anesthesia under these circumstances will be discussed under postoperative complications.

#### PREOPERATIVE MEDICATION

Preoperative medication should be given to relieve anxiety, allay fear, and make the patient less aware of his unaccustomed surroundings. With the accomplishment of these objectives, the patient is usually calm, drowsy, amnesic, and shows signs of reduced metabolic activity.

Our routine medication consists of a combination of narcotics and a sedative, the doses of which are varied according to the age, vigor and metabolic activity of the patient. Morphine sulfate, grain 1/6 (0.01 gm), and scopolamine hydrobromide, grain 1/150 (0.0004 gm), are generally administered subcutaneously one and one quarter hours before operation. The former is a metabolic depressant while the latter promotes amnesia, intensifies the narcosis of morphine, depresses salivary secretion and tends to offset somewhat the respiratory depression of morphine. Pentobarbital sodium (nembutal),  $1\frac{1}{2}$  grains (0.1 gm) or 3 grains (0.2 gm), is administered orally one hour before operation to increase the sedative and amnesic effect of the morphine and scopolamine.

If deeper narcosis seems indicated when the patient reaches the operating room, additional morphine and scopolamine may be administered intravenously.

#### SELECTION OF THE ANESTHETIC AGENT

**Nitrous Oxide**—This weak, nonflammable gaseous agent finds only a small place in our armamentarium. In spite of its low toxicity, the low oxygen concentration allowed with nitrous oxide makes it somewhat undesirable as the sole anesthetic agent for thyrotoxic patients.

whose oxygen requirements are high. Keeping in mind the importance of the oxygen carrying capacity of the blood the real significance of cyanosis with any weak anesthetic agent such as nitrous oxide becomes more apparent. Cyanosis per se means 5 gm. of reduced hemoglobin in each 100 cc. of circulating blood.<sup>6</sup> Therefore a patient with 10 gm. of circulating hemoglobin per 100 cc. of blood when rendered cyanotic with nitrous oxide oxygen anesthesia has but 5 gm. of hemoglobin per 100 cc. of circulating blood available for oxygen transport.

**Ethylene**—Although ethylene is a weak, inflammable explosive gaseous anesthetic agent ranking just ahead of nitrous oxide in potency it has enjoyed a very good record since its introduction by Luckhardt<sup>18, 19</sup> in 1923. Ethylene has been used in thousands of thyroid operations at the Lahey Clinic and no anesthetic death has been attributed to it. However in general, its low potency and low available oxygen content make it undesirable as the sole anesthetic agent for the thyrotoxic patient. Many nontoxic patients can be carried through their operations on 80 per cent ethylene and 20 per cent oxygen. Quick safe pleasant inductions for ether anesthesia can be obtained without cyanosis with this mixture.

**Cyclopropane**—This potent inflammable explosive agent is gradually being placed in its anesthetic niche so to speak. The rapid smooth pleasant induction it provides with high oxygen concentration is often invaluable yet its inherent danger lies in its apparent parasympathetic stimulating effect which predisposes to respiratory depression bradycardia extrasystoles in the thyrotoxic, and on rare occasions to ventricular standstill. After a long experience and thousands of administrations of cyclopropane for thyroid and other operations we have adopted the following policy: *Cyclopropane is not used as the sole anesthetic agent not even for induction, for patients who are severely toxic or have shown any abnormality of the cardiovascular system, that is recent cardiac failure, auricular fibrillation extrasystoles and so forth.* Rather a mixture of cyclopropane ethylene oxygen is used for induction or straight ethylene oxygen is elected. Such inductions are usually followed by light ether maintenance anesthesia.

A mixture of 30 per cent oxygen 60 per cent ethylene and 10 per cent cyclopropane has proved to be extremely valuable for thyroid anesthesia. This mixture is slightly more potent than ethylene-oxygen alone, yet lacks the occasional irritating effect seen with straight cyclopropane oxygen anesthesia when it is superimposed on the thyrotoxic heart. This mixture of cyclopropane ethylene and oxygen generally affords a rapid pleasant induction without cyanosis. The patient

can be maintained on this mixture following induction or ether added to give some increased depth of anesthesia. It is interesting to note that in the laboratory when the concentration of these three gases can be controlled exactly, this mixture is nonexplosive. Although we always consider it an inflammable and explosive mixture when it is used clinically, we believe possibly there are many times during its administration when it is unknowingly in a nonexplosive range.

**Ether.**—The test of time finds anesthetists returning more and more to ether anesthesia for thyroid operations. After a pleasant induction with one of the previously mentioned gaseous agents or mixtures, maintenance anesthesia is carried on with a light concentration of ether or a combination of ethylene-ether or cyclopropane-ether. Because ether-oxygen mixtures rarely ever cause cardiac irritation, they are selected for thyrotoxic patients who show signs of cardiac damage.

**Hazards of Anesthetic Explosions.**—For safety's sake we consider all gaseous anesthetic agents used in thyroid operations to be inflammable and explosive, with the exception of straight nitrous oxide-oxygen. The use of all obviously dangerous devices, such as sparking electric motors, open flames, high frequency electrosurgical units and x-ray machines, is prohibited when ethylene, nitrous oxide-oxygen-ether, cyclopropane, vinyl ether, or ethyl chloride is being administered. Whenever possible, a relative humidity of 55 per cent or over is maintained in the operating room in an attempt to reduce to a minimum the danger of static electricity. At all times as far as possible the recommended safe practices in the use of combustible anesthetics in hospital operating rooms, as set up by the Conference Committee on Operating Room Hazards, are carried out.<sup>11</sup> We take another safeguard against explosions from static electricity by using the Horton intercoupler.<sup>27</sup> This provides a means of electrically connecting the patient, the anesthetist, gas machine and operating table with a high resistant unit interposed between these four members. With such an arrangement no difference in electrical potential can be built up between these bodies, and therefore no static spark can be discharged when one member comes in contact with another member. For a real appreciation of the entire problem, the reader is referred to the comprehensive articles of Horton,<sup>10</sup> Jones and Thomas, and Greene.

**Tribromethanol in Amylene Hydrate (Avertin).**—This nonvolatile agent is used but sparingly for the production of basal anesthesia for thyroid operations as certain undesirable features are often associated with its use. The response of a patient to a given dose of tribromethanol is rather unpredictable, and its removal in case of overdosage is just about impossible. The failure of this form of basal anesthesia to reduce the



pulse rate of thyrotoxic patients has been discouraging and this has further narrowed the indications for its use. Certain theoretical objections can be raised against the use of tribromethanol on the basis that it may further depress the already depressed liver function of the thyrotoxic patient since this agent is detoxified in the liver. Avertin is of value in overcoming the purely nervous symptoms of certain thyroid patients and in the immediate preoperative control of the psychotic thyrotoxic patient. Judicious use of tribromethanol as a form of heavy premedication in children with hyperthyroidism or patients with claustrophobia may be extremely helpful at times.

**Pentothal**—This agent has been used on occasions to render an apprehensive patient unconscious or as an induction agent for inhalation anesthesia. Some difficulty has been experienced with respiratory depression and laryngeal spasms from this usage of pentothal. It does seem, however, that these untoward reactions have been minimized since the 2.5 per cent solution has been used and the speed of administration markedly reduced. A small number of patients have been successfully anesthetized with a combination of 60 per cent nitrous oxide and pentothal or 60 per cent ethylene and pentothal. In the future pentothal alone or in combination with one of the gaseous agents may enjoy a wide field of usefulness in the production of thyroid anesthesia.

#### MANAGEMENT OF OPERATIVE AND POSTOPERATIVE COMPLICATIONS

The ideal management for any complication is to anticipate it and take the proper steps to prevent its occurrence. Thus we attempt to do in dealing with patients suffering from disease of the thyroid gland through close cooperation of the members of the medical, surgical and anesthesia departments. As previously stated, all toxic patients are hospitalized for a ten to twelve day period of intensive preparation. Close attention is paid to signs of improvement as shown by gain in weight, reduction in pulse and basal metabolic rates and a decrease in nervousness and restlessness. Thiouracil medication is given to those patients with evidence of widespread visceral strain as shown by great weight loss or cardiac complications.

Roentgenograms of the chest and trachea are obtained if intra-thoracic extension of the thyroid gland is suspected. A preoperative examination of the vocal cords is made when abnormal laryngeal function is suspected or the patient has had a previous thyroid operation. In this way the need for endotracheal anesthesia is discovered before the patient undergoes his operation.

All patients are seen on a preanesthetic visit by a member of the anesthesia department the evening before their scheduled day of opera-

tion. An evaluation of the anesthetic risk they present is made and all positive information recorded on the anesthesia sheet.<sup>20</sup> Those patients presenting anesthesia problems are discussed with the members of the medical and surgical departments caring for them. Then, with all this information at hand, the preoperative medication is ordered and the anesthetic agent and method is decided upon. In spite of this careful regimen to prevent operative and postoperative complications, a certain, almost unavoidable minimum do occur and a discussion of their management by the anesthetist follows.

**Excess Mucus.**—During the course of anesthesia excess mucus can be extremely troublesome and frequently must be aspirated from the naso-

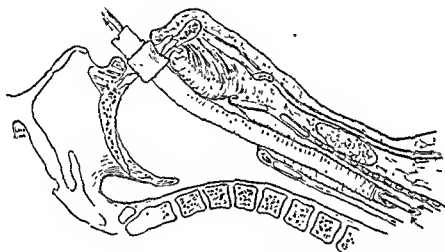


Fig. 290.—Method of removing mucus from the trachea and pharynx when an endotracheal tube has been employed. The suction catheter protrudes 1 inch from the distal end of the tube to remove excess secretions from the distal part of the trachea.

pharynx with a soft rubber catheter of appropriate size. Trauma and the injudicious use of strong suction must be avoided if hemorrhage is to be circumvented when this is done. When an endotracheal tube is in place the catheter is passed through the tube and mucus removed from the tracheobronchial tree. As this mucus is secreted in the mouth and nasopharynx and passes down around the endotracheal tube into the trachea, it is necessary to remove it from the pharynx at the same time the endotracheal tube is cleared. Much of the postoperative difficulty from excess mucus in the tracheobronchial tree can be eliminated if this excess mucus is removed by tracheal or nasopharyngeal aspiration at the close of each operation (Figs. 290, 291 and 292).

**Hemorrhage.**—This is one of the greatest potential dangers in thyroid surgery because of the rich blood supply of the thyroid gland and

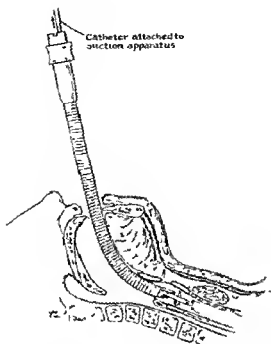


Fig 291—The suction catheter is allowed to remain in position shown in figure 290 so that mucus along the trachea and in the pharynx can be removed with withdrawal of the endotracheal tube

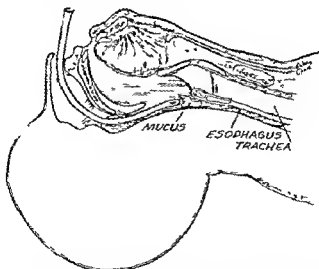


Fig 292—Method of removing collection of mucus from the pharynx by passing a suction catheter through the nasopharynx

the proximity of the great vessels of the neck. Those patients coming to operation with extremely large adenomatous goiters or cancer of the thyroid should be scheduled for transfusion because of the possibility of severe hemorrhage taking place. Hemorrhage which occurs during the operation can be readily seen by the anesthetist and the indicated measures to combat it with intravenous administration of saline solution, glucose, plasma and blood should be taken. During the post-operative period when hemorrhage takes place, it may be necessary to open the operative wound rapidly and remove the clots in order to relieve the pressure on the trachea so that the patient can breathe.<sup>15</sup> With this accomplished, pressure may be applied to control the bleeding, and the patient returned to the operating room where a surgical closure of the wound can be accomplished under anesthesia if necessary.

**Hole in the Trachea**—A hole may accidentally be cut in the trachea at any time. However, this complication is not so likely to occur at the first operation as it is at secondary operations on the thyroid gland. The anesthetist should recognize what has happened and increase the flow of gases so as to keep positive pressure in the trachea during all phases of respiration. With positive pressure maintained in the tracheo-bronchial tree, anesthesia can be maintained and no blood or debris will be aspirated into the trachea while the surgeon closes the tracheal defect.

**Carotid Sinus Syndrome**—Any sudden, severe, simultaneous drop in pulse rate, blood pressure and respiration should make one think of the stimulation of a sensitive carotid sinus. Successful treatment depends on early recognition, interruption of the operation, lowering the patient's head, and effective artificial respiration. Ten cubic centimeters of 1 per cent procaine should be injected at the bifurcation of the carotids on the side in question and atropine sulfate, grain 1/100, should be injected intravenously in an attempt to depress the vagal influence in this syndrome.<sup>16-18</sup> These patients usually make a rapid and complete recovery when the source of stimulation to the sensitive carotids is removed.

**Air Embolus**—This is a rare happening but must be borne in mind when the surgeon is dealing with large veins in the area of the thyroid gland. A sucking noise is heard especially on inspiration, and almost as suddenly, the pulse, blood pressure and respiration disappear. Unless the open vein is closed with dispatch, a fatality is almost inevitable.

**Extreme Toxicity**—In spite of careful preoperative preparation and adequate premedication, one occasionally sees a patient come to the operating table with marked tachycardia. Most often this is a sign of

pure nervous instability rather than toxicity. However, the only way to distinguish the two conditions I believe, is by inducing general anesthesia. The tachycardia of nervous origin will subside, while the severely toxic patient will show little drop in pulse rate and should have more preparation before operation is undertaken. We have no hesitancy in cancelling the operation when this extremely unusual response is seen.

**Convulsions under Anesthesia.**—This is another rare but, indeed alarming and frequently fatal complication. Almost all convulsions start with twitchings around the eyes which rapidly spread to contractions of the facial muscles and then generalized tonic and clonic contractions of the muscle groups of the entire body. The etiology of these convulsions is seldom clear, but one must think of a possible cocaine reaction if this material has been used, tetany, carbon dioxide excess, or a neurotoxin or poison produced by some strains of streptococci which, according to Rosenow and Tovell, are frequently found in the nasopharynx of patients who have convulsions under general anesthesia. The anesthetist's first consideration is to stop the convulsion, and this can usually be done by the judicious intravenous administration of a soluble barbiturate, such as pentothal sodium. At the same time effective artificial respiration must be carried on to prevent the damages of anoxia. As treatment in such instances must be rapid and general rather than specific, it is well to administer calcium gluconate against the possibility of tetany, discontinue ether if it is being used, change to fresh soda lime to insure adequate carbon dioxide removal from the anesthetic mixture, and start the intravenous administration of glucose and saline solution.

**Postoperative Pulmonary Complications.**—Since most toxic patients show some reaction after operation, great care must be exercised in evaluating the cause of such a reaction. Elevations of temperature, pulse and respiration may come from pulmonary atelectasis or early pneumonia as well as from thyroid toxicity. Troublesome collections of mucus are often seen after operation in those patients whose upper respiratory tract has sustained trauma from pharyngeal airways, nasopharyngeal or endotracheal tubes. Difficulty in raising mucus is frequently seen after operation in a patient whose trachea has previously been distorted by pressure from the thyroid gland or when large drains have necessarily been left after the removal of an intrathoracic goiter. Not infrequently, a distended stomach will be found as a cause for fluid in the tracheobronchial tree. The relaxation of sleep in the presence of a dilated stomach allows fluid to escape into the esophagus and up into the pharynx where it is aspirated. Therefore it is important

that a distended stomach not be overlooked as a possible cause for excess fluid found in a tracheobronchial tree after operation

Whenever a patient demonstrates his inability to raise mucus from his tracheobronchial tree after a trial of coughing and frequent changes of position, it must be raised for him either by tracheal aspiration with a large rubber catheter (Fig 293) or by bronchoscopy<sup>8</sup>

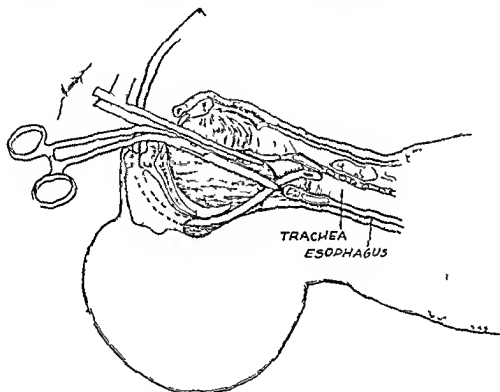


Fig 293—Method of guiding aspirating catheter into the trachea under direct vision

### TRACHEOTOMY

Postoperative bilateral cord paralysis or marked edema of the false cords generally makes tracheotomy necessary. This condition is often heralded by stridor, cyanosis and even unconsciousness from prolonged hypoxia. However, even in the presence of bilateral cord paralysis the patient may retain the ability to talk, but will complain of frequent choking spells whenever he attempts to drink or eat. When such a condition is suspected the vocal cords should immediately be examined by laryngoscopy. If bilateral cord paralysis is present or the glottic opening found to be closed from edema of the false cords, tracheotomy is mandatory. This is facilitated by taking the patient to the operating room where general anesthesia can be administered, using a mixture of helium, oxygen and cyclopropane if necessary, and endotracheal

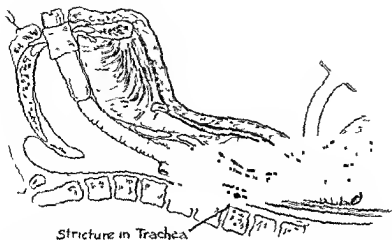


Fig. 294—Relative position of tracheotomy opening and end of endotracheal tube are shown. The latter is withdrawn just enough to allow introduction of tracheotomy tube into trachea, as shown in Figure 295.

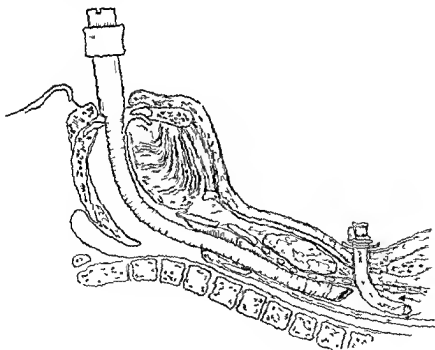


Fig. 295—Nose

intubation accomplished. With this set up, the anesthetist has full control of the patient, and the tracheotomy may be carried out according

to a definite plan, without hurry or worry to the surgeon, and the operative field kept sterile at all times. When the hole is made in the trachea by the operator, the endotracheal tube will be found lying in the tracheal lumen. The endotracheal tube is withdrawn just far enough to allow the tracheotomy tube to be inserted and, with an adapter on the end of the endotracheal tube and the opening in the tracheotomy tube plugged with the obturator, the anesthesia may be maintained by allowing the patient to breathe through the gas machine<sup>24</sup> (Figs 294 and 295).

The chest of these patients should be carefully investigated for possible areas of atelectasis as this condition is frequently associated with glottic obstruction from edema or cord paralysis. When the vocal cords are fixed in the midline the patient is unable to cough up mucus from the tracheobronchial tree and it soon collects in amounts large enough to block parts of the air passage.

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## THIOURACIL ITS USE IN THE PREOPERATIVE PREPARATION OF PATIENTS WITH SEVERE HYPERTHYROIDISM

ELMER C. BARTELS

THIOURACIL has been used in the preoperative management of severely toxic hyperthyroid patients at the Lahey Clinic since May 1943.<sup>1 2 3</sup> We were early convinced of the striking effectiveness of this drug and have continued to use it for all patients who are so severely toxic as to incur more than the average surgical risk if prepared in the usual manner by the administration of Lugol's solution. Patients with mild hyperthyroidism continue to be prepared with iodine since in this group sufficient improvement occurs to permit thyroidectomy without risk.

This report gives the results of our experience with the first 100 patients who were treated preoperatively with thiouracil\* and have gone through thyroidectomy. Both types of hyperthyroidism were represented in the group—eighty-one patients had primary hyperthyroidism or Graves' disease and nineteen patients had adenomatous goiter with hyperthyroidism.

There were eighty-five females and fifteen males. The ages varied from eleven to seventy-seven years, the average age was forty-five years. Forty-four patients were over fifty years of age. The average duration of the hyperthyroidism was twenty-four months. Forty-three patients had had hyperthyroidism for more than two years. Of these, eleven had been ill for more than five years. Twenty-five of the 100 patients had lost more than 40 pounds, with the average weight loss being 25 pounds. One patient had lost 98 pounds.

The initial basal metabolic rate varied from +21 to +98 per cent, with the average rate being +49. Fifty-four patients had rates over +45 per cent.

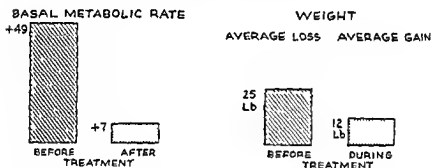
All of these 100 patients were considered to have severe hyperthyroidism because most of them were in the older age group, they had had the disease for a long time and had high basal metabolic rates. Seventeen patients were classified as thyrocardiacs, having either heart failure or auricular fibrillation without heart failure. This latter group of patients has in the past carried a very high surgical risk since cardiac complications imply advanced thyroid disease.

\*The thiouracil was obtained from the Lederle Laboratories, Pearl River, New York.

## PLAN OF TREATMENT

Patients without heart failure are treated as outpatients. The first ten days is spent at bed rest and then the patient is permitted to get up and gradually increase the time up and about as his condition permits until fairly normal activity is established before operation. A high caloric diet is urged, with three full meals a day and lunches between meals. Patients with heart failure are hospitalized for ten to fourteen days, during which time the usual measures for congestive failure are instituted, including bed rest, administration of diuretics and full and maintained digitalization. After compensation is restored, the patient is discharged and further preoperative treatment is carried on at home. The patients are seen every two weeks for routine examination and

THIOURACIL IN PREOPERATIVE  
TREATMENT OF SEVERE HYPERTHYROIDISM  
RESPONSE IN 100 CASES



AVERAGE DURATION OF TREATMENT 57 DAYS

Fig. 296

white and differential blood counts. If suspicious changes in the blood are observed, the patient is seen more often, either in the Clinic or by the referring physician.

Administration of thiouracil is begun in the daily dose of 0.6 gm, 0.2 gm being given at 7 A.M., 2 P.M. and 9 P.M. The full dose is continued until the maximum benefit is obtained, at this point all hyperthyroid manifestations will have subsided, with the basal metabolic rate being normal. Our early experience with the use of thiouracil taught us that thyroidectomy should not be attempted before optimum improvement is obtained since prior to this time an unsatisfactory anesthetic course and alarming postoperative reactions may occur, thereby defeating the value of thiouracil therapy.

The time required to accomplish the desirable degree of improvement is determined fairly accurately from the height of the basal metabolic rate. It has been found that approximately one day of treatment with 0.6 gm. of thiouracil is required for each percentage of elevation in the basal metabolic rate. Those patients who have received Lugol's solution before the administration of thiouracil responded less quickly and usually required a slightly longer period of treatment. Those patients who had hyperthyroidism of short duration, two to three months responded more quickly to treatment. Those patients with very large glands responded more slowly, but on the whole, the size of the gland did not seem to be a factor in the duration of treatment. With this knowledge, the date of readiness for operation can be estimated and hospital arrangements can be made in advance. In no case was there failure to respond satisfactorily to treatment.

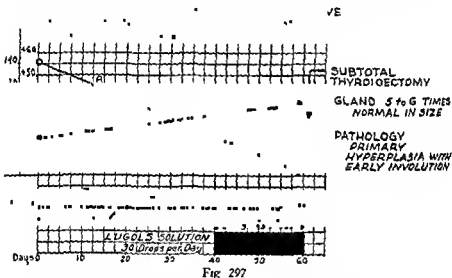
The average basal metabolic rate (Fig. 296) after an average of fifty-seven days of treatment was +7. Three patients received thiouracil for over one hundred days and fifty-nine patients for over fifty days. The average gain in weight was 12 pounds with nineteen patients gaining over 20 pounds.

#### OPERATIVE PROCEDURES

Fifty-seven patients were subjected to subtotal thyroidectomy, and thirteen patients to hemithyroidectomy. Of the latter thirteen patients four had very large goiters and it was thought at the time unwise and perhaps not feasible to do a subtotal thyroidectomy. This occurred early in our experience and before we had learned about the smooth anesthesia and postoperative course of patients treated adequately with thiouracil. Since speed is no longer necessary, extremely large glands are now removed at one stage. Four patients were not treated long enough with thiouracil to permit subtotal thyroidectomy without risk, as indicated by an unsatisfactory anesthesia course. These also occurred early in our experience before optimum improvement prior to operation was thought necessary. Four patients were prepared for second stage operations with thiouracil after having had the first stage procedure performed following iodine preparation because their condition after the first operation was thought to be too serious to warrant a second stage procedure without considerable risk. One patient had only a hemithyroidectomy because of the extreme technical difficulty in removing a recurrent goiter, and it was thought the patient had undergone anesthesia sufficiently long to limit the operation to one lobe. There were no postoperative deaths.

When the first patients receiving thiouracil underwent thyroidectomy, a most unsatisfactory surgical complication was encountered

The gland was found to be soft and friable, and bleeding of the entire operative site was so extensive that there was difficulty in carrying out the usual surgical technic, including the isolation of the parathyroid glands and the recurrent laryngeal nerve. Some of our surgeons disliked operating on these patients for this reason. This difficulty was overcome when Lugol's solution was administered along with thiouracil. Iodine is given daily during the three week preoperative period and the thiouracil is discontinued one week before operation, as indicated in Figure 297. In this typical case with severe hyperthyroidism with a basal metabolic rate of  $+55$ , 0.6 gm of thiouracil was given daily for fifty-four days, discontinuing its administration one week before operation, and Lugol's solution was given daily during the



three week preoperative period. The basal metabolic rate before operation was  $+6$ . The iodine given preoperatively produces firmness of the gland, which seems to become soft during thiouracil treatment, and the palpable thrills and bruits become less marked. At operation the gland in this case was sufficiently firm so that no technical difficulty was encountered.

Iodine is not required preoperatively in patients with adenomatous goiters or in patients who have had long standing primary hyperthyroidism. In the former cases, the gland is not altered during therapy and in the latter cases, spontaneous involution over the years has caused the gland to become firm and granular, and rarely are thrills and bruits present. This type of gland does not change during thiouracil treatment.

In patients adequately treated with thiouracil the pulse remains constant, as does the blood pressure, during anesthesia, in contrast to the rising blood pressure and pulse rate in patients treated with Lugol's solution (Fig. 298) No evidence of toxicity is observed, the course

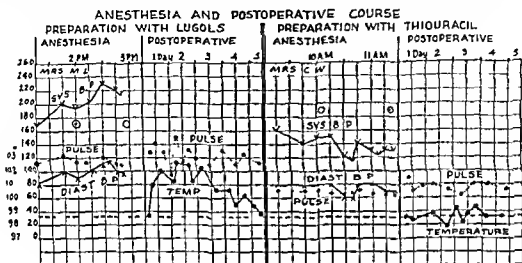


Fig 298

being that seen during the removal of a nontoxic adenomatous goiter. Just as the anesthesia course is satisfactory so the postoperative course is void of reaction. The worry and concern over thyroid patients after operation have now been entirely eliminated. Intensive sedation, fluids and oxygen administration are no longer necessary.

#### TOXIC REACTIONS OF THIOURACIL

Toxic manifestations developed in twelve patients, only five\* of whom are in the operated group mentioned. The reactions consisted of skin eruption in three patients, fever reaction, four patients, leukopenia, three patients, and edema of the skin, two patients. The *skin eruption* was generalized, finely macular papular in type, and was quite pruritic. Relief was promptly obtained on stopping treatment. This complication usually occurred in the third or fourth week of therapy. *Fever reactions* occurred at the end of the first ten days of treatment. The temperature ranged from 102 to 103° and was associated with generalized muscular aches and pains. The symptoms subsided promptly when administration of thiouracil was discontinued. In these three cases a repeated small dose, 0.1 gm., of the thiouracil caused an immediate return of fever and muscular aches and pains. *Edema of the skin* occurred at about the end of treatment and was noticed in the skin of the arms and legs. The patient felt muscle bound, with the skin ap-

\*Twelve of a total of 140 patients who were given thiouracil during this time

pearing as it does in the early stages of scleroderma. These patients were not myxedematous.

The most serious and alarming reaction was the development of *leukopenia*. This occurred after two months, eight months and ten months of treatment in three cases, the dose of thiouracil being 0.3, 0.1 and 0.05 gm. daily, respectively. The changes were quite sudden with a reduction in the total white count and in the polymorphonuclear cells. A return of the blood to normal quickly followed discontinuance of the drug. One patient presented the early stages of *granulocytic angina*. Fortunately, the condition was recognized early and the drug was stopped, with prompt return of the blood to normal. These changes in the blood make frequent blood examinations essential during the administration of thiouracil.

A great economic saving was possible by the use of thiouracil in this group of hyperthyroid patients. The hospital stay now is seven to ten days as compared with weeks when patients were prepared with Lugol's solution. The expense of multiple operations is also eliminated.

#### SUMMARY

Thiouracil is a most valuable drug in the preoperative management of patients with severe primary hyperthyroidism or adenomatous goiter with secondary hyperthyroidism.

The drug must be administered until maximum benefit is obtained and at that time operation can be carried out without risk.

The technical difficulties at operation which occurred in patients treated only with thiouracil have been overcome by the added use of Lugol's solution during the three week period immediately before operation.

Since thiouracil cannot be given without danger, patients must be carefully observed during the preoperative period for any signs of toxicity. The blood changes are of greatest potential danger, so frequent blood tests are imperative to avoid difficulty.

The true value of thiouracil in hyperthyroidism lies in the reduction of the risk of surgical treatment which we believe is still essential to terminate hyperthyroidism with greater certainty and greater safety.

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# TEN TO TWENTY YEAR RESULTS FOLLOWING SUBTOTAL THYROIDECTOMY FOR PRIMARY HYPERTHYROIDISM

A Preliminary Report on 1016 Patients Operated upon before 1927

IRVING M. HURWITZ, CARLTON R. SOUDERS, JOHN D. DE PERSIO  
AND NATALIJA MUSULIN

SUBTOTAL thyroidectomy has been and may continue to be the most satisfactory method of treatment for hyperthyroidism. From the simpler operations of pole ligations and hemithyroidectomy which failed to produce little if any lasting benefit, to the removal of a greater part of the gland which often left persisting and over-active remnants, the operation has finally been developed to one of radical subtotal removal which appears to have eliminated a fairly large number of cases with persistent hyperthyroidism. The evolution of the present technique of subtotal thyroidectomy has been the natural result of repeated follow-up studies over a period of years. The introduction of thiouracil has almost eliminated the necessity for stage operations and has lowered mortality.

In a recent study of 1016 cases of primary hyperthyroidism or Graves disease in which operation was performed before 1927 we were able to determine the outcome of 643 cases. These patients were followed for periods varying from ten to twenty years, as listed in Table 1. Of the remaining cases numbering 373, not followed for a

TABLE 1—LENGTH OF FOLLOW-UP

No. Years Followed	No. Patients	No. Years Followed	No. Patients
10	76	16	66
11	98	17	23
12	68	18	13
13	45	19	5
14	101	20	3
15	91		

Total number of patients 589

period of ten years, many were often seen up to five or six years after their operation. The results in this latter group were essentially the same as in the former group for the number of years followed.

This follow-up, therefore, represents a fairly long study of the subsequent life histories of patients who have been submitted to thyroid



surgery. When first examined, none of the patients had recurrent hyperthyroidism following operation elsewhere or in this Clinic. Cases of toxic adenomatous goiter were not included in this group. It is realized that Graves' disease may be superimposed upon an adenomatous goiter and that a sharp distinction cannot always be made between the two.

As stated before, subtotal thyroidectomy in this Clinic prior to 1927 was not the radical procedure that it is today. This group consists of 1016 unselected cases in which surgical procedures were carried out in the pioneering days so to speak. A number of this group were operated upon before the introduction of Lugol's solution as a pre-operative preparation, hence more stage operations were done in those cases than are done today.

It has been surmised that exophthalmic goiter today is not as severe as it was before 1927. It would be difficult to arrive at any definite conclusion as the result of statistical analyses because so many vari-

TABLE 2—OUTCOME TEN YEARS OR MORE AFTER  
SUBTOTAL THYROIDECTOMY

Postoperative deaths	16
Died before 10 years	39
Lived 10 years; died thereafter	25
Living at time of follow up 10-20 years	564
Untraced after 10 years	372
Total number operated upon	1016

ables are involved. In the first place it is likely that many more cases, particularly early cases, are recognized now than twenty years ago. Iodine is used more frequently so that hyperthyroidism is less intense when the patient is referred for operation.

The average metabolic rate of the group studied here was not determined, the cases being grouped according to various levels of metabolism. It was, however, shown that 62.1 per cent of the patients had a basal metabolic rate of over +50 per cent on admission to the hospital in the group operated on before 1927, and that only 21 per cent of cases after 1939 had a basal metabolic rate of +50 or more. These findings naturally do suggest that exophthalmic goiter today, even considering the effect of iodine, is not as severe as it was formerly. A more detailed study, however, would have to be made to confirm this suggestion.

Table 2 shows the outcome ten years or more after subtotal thyroidectomy. Sixteen patients in this group died postoperatively. Three

other patients died at home of severe hyperthyroidism before returning for their first, second or third operation. Eight other patients who had persistent or recurrent hyperthyroidism died before ten years, but it was not known definitely whether the hyperthyroidism contributed to their death. It might be stated here that in this group no patient was included who died in the hospital from severe hyperthyroidism before operation could be performed. Before the year 1927 the number of patients who died in thyroid crisis before any surgical procedures could be carried out probably outnumbered those dying postoperatively.

The distinction between persistent and recurrent hyperthyroidism is, at times, difficult, and the distinction is an arbitrary one at best. For the purposes of classification, however, a patient who shows persistent toxicity three months after the operation has been considered in this Clinic to have persistent hyperthyroidism. Patients who have had a normal metabolic rate at the end of three months and showed no clinical signs of hyperthyroidism were then considered as recurrent cases if hyperthyroidism was found subsequently. During the period when the patients herein reported were operated upon, it was our practice to prescribe 10 drops of Lugol's solution once a day for the first three postoperative months. This tended to obscure a mild persistence of hyperthyroidism as well as to lower the average metabolic rate at the three month postoperative examination. Not a few patients had normal metabolic rates who on discontinuing Lugol's solution revealed persistent hyperthyroidism at six months. These cases, therefore, can rightly be classified as examples of persisting hyperthyroidism.

The number of patients with persistent hyperthyroidism whom we see now at the end of three months, even though iodine is not used during this period, is comparatively small, in fact we rarely see them. The difference between persistent hyperthyroidism at three months and recurrent hyperthyroidism at nine months may have been a matter of how much thyroid tissue was left, other factors being equal.

The relationship of the amount of thyroid tissue removed to the subsequent metabolic rate can be demonstrated by reviewing certain well known observations, hemithyroidectomy decreases the average metabolism approximately one half, at least for a six week to two month period thereafter, total ablation of the thyroid produces mixed edema. In looking at Table 3 it can be shown, as might be expected, that the basal metabolic rate obtained at three months has some bearing on the time of recurrence of hyperthyroidism, especially in the low metabolic group. Those patients who had a metabolic rate of below -10 per cent developed this rate either because a little too

radical procedure was carried out or because the activity of the thyroid tissue left behind was normal or subnormal. Thus, before sufficient thyroid hormone can be produced in excess of the normal amount, a greater length of time will be necessary to develop clinical hyperthyroidism, other things being equal. It is to be noted that recurrent hyperthyroidism did not develop in any of the eight cases with a metabolic rate of  $-25$  or below. This is not always true because we have noted occasionally that individuals who have developed post-operative myxedema subsequently, although not for a period of several years, showed recurrent hyperthyroidism (see p. 669).

TABLE 3—INCIDENCE OF RECURRENT OR PERSISTENT HYPERTHYROIDISM IN RELATION TO BASAL METABOLIC RATE THREE MONTHS AFTER OPERATION

Range of BMR 3 mos Postop	No. Cases BMR Done	No Recurrences before 3 yrs	No Recurrences after 3 yrs	Per cent in Metabolic Group	
				Recurrence	Persistence
$-25$ or below	8	0	0	0	
$-24$ to $-10$	57	0	6	11.5	
$-9$ to $+20$	131	10	20	9.0	
$+21$ to $+50$	37	29	7*	18.9	78.4
$+50$ and above	7	7	—		100.0

\* Although these patients had a metabolic rate between  $+21$  and  $+30$  at the end of three months they appeared normal in every way until a definite recurrence took place later.

If the cause of primary hyperthyroidism were known it might be possible to determine which cases would be likely to have a recurrence or persistence of hyperthyroidism, but unfortunately this is not possible. It does appear, however, that the greatest percentage of recurrence or persistence occurred in patients with the highest metabolic rates. This would indicate that the underlying cause of hyperthyroidism is operating with greater than average drive and since subtotal thyroidectomy probably does not remove the cause, the tendency to develop the recurrence is therefore greater. This tendency, as shown by a small group whose symptoms are most difficult to control, along with the amount of thyroid tissue removed, would seem to influence the time and likelihood of recurrence.

If we assume as we have done that the number of persistent cases seen in recent years is less because more thyroid tissue is removed than formerly, it will hardly explain the continuation or recurrence of the disorder in that group which has been so difficult to control in spite of several operations. Furthermore, if we conclude that the disease is not fundamentally less severe in recent years than at the time these patients were operated upon, then one might speculate that another factor may influence the persistence of hyperthyroidism, namely, the time interval in which sufficient amount of thyroid tissue is removed to reestablish a normal hormonal balance. This brings up the long mooted question of why subtotal thyroidectomy does produce such satisfactory results. Does it do so because of the abrupt hormonal readjustment?

It has been our policy to give patients with persistent or recurrent hyperthyroidism a trial of Lugol's solution if they are not severely toxic. This diminishes the output of the thyroid hormone and in many instances brings the metabolic rate to normal and a clinical response which is satisfactory. In spite of iodine, however, some people continue to be thyrotoxic and subtotal thyroidectomy has again been advised. In other cases iodine has controlled them only for a variable period of time until clinical toxicity has finally appeared, suggesting an intensification of the underlying cause. Even in cases in which iodine has produced a satisfactory clinical response the thyroid remnants may increase in size to a marked extent. In a few cases in which reoperation was not considered advisable and iodine did not completely control symptoms roentgen therapy was used. More recently, thiouracil has been used in recurrent or persistent cases except in those cases not under our direct observation. One interesting feature noted in two cases of persistent hyperthyroidism which were controlled with Lugol's solution and in which normal metabolic rates were found, was the improvement in well being when thiouracil was substituted for Lugol's solution.

There is a small but important group of individuals, less than 3 per cent of the total, who continue to develop hyperthyroidism even though temporarily controlled by surgical removal, iodine or x rays. In this group of cases it would seem almost necessary to produce myxedema in order to prevent a recurrence. Roentgen treatment has not been permanently successful in these cases unless at least twelve to eighteen treatments of 300 r each have been used and in some instances recurrence has taken place even though patients had myxedema for some time (see p. 668).

End results were estimated on the basis of the following criteria

<i>Excellent</i>	No complaints patient in good health
<i>Good</i>	Persistent auricular fibrillation, persistent hyperthyroidism controlled, or myxedema controlled with thyroid. All in satisfactory condition
<i>Fair</i>	Able to be about, condition fair, but not always because of abnormal thyroid function, if present
<i>Poor</i>	Usually incapacitated, in poor health, not always the result of thyroid disorder. Includes uncontrolled hyperthyroidism.

On this basis, of 589 living patients followed, the results were considered excellent in 386, good in 139, fair in 38 and poor in 26, to the end of the follow-up

The results are summarized in Table 4

TABLE 4—RESULTS

Permanent tetany	7	} of 1000 cases
Transient tetany	4	
Unilateral cord paralysis	2	
Bilateral cord paralysis	1	
Permanent auricular fibrillation since operation	33	
Permanent myxedema	49	
Temporary myxedema	12	
Subsequent postoperative deaths for recurrent hyperthyroidism	2	
Subsequent deaths	64	
Died of hyperthyroidism—incomplete surgery	3	
Died with recurrence present	1	
No. of first recurrences after first operation	53	
No. of persistent cases after first operation	64	
Died with persistence present	3	
Died with possible persistence present	5	
No. of second recurrences after operation for first recurrence	4	
No. of recurrences after first operation for persistent hyperthyroidism	13	
Total first and second recurrences including those dead (643 cases)	73	(11.3 per cent)

## MYXEDEMA AND ITS VARIOUS CAUSES

LEWIS M. HURTHAL

A DEFICIENCY of thyroid hormone produces changes which, when of sufficient duration or degree, cause the clinical state of myxedema. Hypothyroidism without myxedema is usually a misnomer, but there is little doubt that it may occasionally exist and be difficult to recognize.

### DIAGNOSIS OF MYXEDEMA

There are several ways of verifying the presence or absence of myxedema in doubtful cases exclusive of the basal metabolic rate which if low, does not always indicate thyroid deficiency. In a large group of patients without thyroid disease, Boothby, Berkson and Plummer showed that the incidence of metabolic rates below  $-10$  was approximately 9.6 per cent, below  $-15$ , 2.7 per cent, and below  $-20$ , 0.4 per cent. If one calculates the incidence of spontaneous, that is, not postoperative myxedema, as reported from various parts of the country as between 0.5 to 1.5 per cent of hospital admissions (1.4 per cent at this Clinic), then one realizes that when a metabolic rate of  $-10$  or below is found, the probability of thyroid deficiency is only one in ten.

Likewise, while a high blood cholesterol is characteristic of myxedema it is by no means pathognomonic. In a series of 300 cases of hypercholesterolemia at this Clinic, we found 40 per cent were cases of myxedema. While probabilities do not make a diagnosis, they do reveal the limitation of these determinations. The following general statements as to probabilities can therefore be made:

1. One case in two with a basal metabolic rate below  $-20$  may be due to myxedema.
2. Four cases out of ten with a blood cholesterol over 300 mg. may be due to myxedema.
3. Two cases of myxedema out of every 100 may have a normal metabolic rate of  $-10$  to  $+10$ .
4. Five of every 100 cases with myxedema may have a normal cholesterol (range 160 in childhood to 260 in old age).
5. Nine patients of every ten with a metabolic rate below  $-20$  and a cholesterol over 300 mg. probably have myxedema.

Additional methods of examination such as the total blood iodine, plasma bound iodine, creatine excretion, all of which are low, are

useful when they can be carried out but are not practical for routine diagnosis. The determination of retardation of bone age in children is useful if thyroid deficiency has been present several years or more, it does not, however, exclude other forms of dwarfism. If bone age is not retarded in a child whose condition is of several years' duration, and who has not been treated, thyroid deficiency is not present.

The thyroid gland may produce less hormone than usual in hypopituitarism without producing myxedema. Here one might say that hypothyroidism existed without myxedema. In cases of pituitary chromophobe tumor with very low metabolic rates and normal blood cholesterol, but with normal electrocardiographic and circulation rates we do not usually see the mental and physical changes of myxedema. In defense of hypothyroidism without myxedema, a selective deficiency of pituitary thyrotropic hormone could be considered, but of this we have no proof. Even if this is eventually established, it too would be consistent with the hypothesis that myxedema results from thyroid deficiency in an individual whose pituitary gland otherwise is functioning normally. Housay demonstrated that hypophysectomy in animals resulted in a low metabolic rate after which removal of the thyroid caused a further reduction. Removal of the thyroid without hypophysectomy produced the same depression of metabolism. These experiments tend to show that the thyroid is capable of some function even after the influence of the pituitary is removed. If this is true it does not explain the rare cases of pituitary myxedema, a condition in which the physical features are indistinguishable from primary thyroid myxedema unless the thyroid stimulating factor is depressed out of proportion to other pituitary secretions. We know that of the various pituitary secretions, some are more depressed than others in the hypopituitarism of pituitary tumor. Pituitary myxedema may be the result of hypopituitarism of long duration. Another possibility is that the thyroid gland in some way is affected independently, such as occurs in spontaneous myxedema in which thyrotropic hormone is in excess. The role played by Collip's metabolic hormone of the medial lobe of the pituitary has not as yet been assigned in this complicated hormonal interplay. In our experience, desiccated thyroid does not produce as satisfactory a response as it does in primary myxedema.

#### CLASSIFICATION OF CAUSES

The causes of myxedema may be classified in various ways. From the anatomical or surgical viewpoint, the following has been arranged

## MYXEDEMA WITH GOITER

- 1 Nodular goiter
  - a Congenital
  - b Sporadic
  - c Endemic
- 2 Diffuse goiter (may be slightly nodular)
  - a Chronic thyroiditis
    - Hashimoto type
    - Riedel type
  - Specific infection syphilis, tuberculosis pyogenic, actinomycosis
- 3 Hyperplastic goiter
  - a Spontaneous cessation in Graves' disease (?thyroiditis present)
  - b Inactive from iodine
  - c Inactive from x rays
  - d Inactive from thiouracil

## MYXEDEMA WITHOUT GOITER

- 1 Primary myxedema
  - a Congenital absence of thyroid
  - b Idiopathic atrophy
  - c As under 3 above when gland is small
  - d Postoperative myxedema
- 2 Secondary myxedema
  - a Pituitary tumor (chromophobe)
  - b Pituitary deficiency without tumor

## MYXEDEMA OF INFANCY OR CHILDHOOD

Hypothyroidism is damaging to normal mental development especially in infancy and it would appear to be so in proportion to its duration before treatment. Facilities for intensive study of borderline cases are impossible in many instances. When such is the situation, the administration of adequate doses of thyroid is justified since no time should be lost. No harm can come from giving  $\frac{1}{2}$  to 1 grain of desiccated thyroid to an infant or child, it should be discontinued if no definite improvement occurs within one to two months. Nowadays blood cholesterol determinations are done in most laboratories so that a routine examination of this sort in all such cases would undoubtedly reveal the diagnosis in the majority. Excluding those diseases most likely to be associated with hypercholesterolemia in children, such as xanthomatosis, nephrosis, an elevated blood cholesterol of 200 mg or more justifies thyroid administration.

In our experience mongolism has been the one disorder most commonly mistaken for infantile myxedema. There is little reason for this as it can be distinguished at a glance. Before being seen in the Clinic, many patients had been treated with thyroid, and apparently with



some improvement according to parents. Since there is retarded bony development in mongolism, thyroid may be helpful in a nonspecific way as it appears to be in other cases of dwarfism. There should be no objections to its use in these cases as long as it is made known that the disorder is not of glandular origin. That there may be an associated thyroid deficiency is not at all impossible and may explain the results claimed for thyroid administration. We have made no subsequent observations in cases of mongolism which we have been asked to see to settle the question of glandular disorder, having gained this impression from the history and such data as were available when the patient was examined.

Retarded development associated with goiter can almost always be assigned to thyroid deficiency. If hyperthyroidism is present there may be failure to gain weight or actual loss, but all other features should not be confused with thyroid deficiency.

In childhood, the differential diagnosis includes all forms of retarded growth. The degree of infantile or childhood myxedema or cretinism is a factor in its recognition. When such has existed for a long time, few will fail to recognize the disorder. In early infancy this may be extremely difficult but should always be suspected when the child does not develop satisfactorily. Later, when failure to walk or talk at the usual age occurs, or if there is delayed dentition, thyroid deficiency is always a possibility. Should hypothyroidism begin at any age it is doubtful if it would be recognized before a year's existence. Creatine retention and low blood iodine are the usual findings. Blood cholesterol is particularly valuable since basal metabolic rates are impractical. The bone age is retarded, the centers of ossification being particularly delayed, but since the bone age cannot be estimated earlier than one or two years at most, it is apparent that such an underdevelopment would be of little value in a case of short duration.

#### MYXEDEMA AND ADENOMATOUS GOITER

Myxedema may be present with adenomatous goiter in infants, children or adults. As stated before, if thyroid deficiency has existed long enough in the young, the clinical features of cretinism may be present. In contrast to cretins without goiter, the adenomatous gland may have a return of thyroid function to normal, thus eliminating all signs of concurrent thyroid deficiency but exhibiting the stigmata of an earlier one. The infantile facies of cretinism may persist but if the duration of the period of thyroid deficiency was relatively short, that stigma may not be obvious. Retarded growth or height age

along with retarded bone age is the reliable residual of such a previous deficiency. Mental age too is usually retarded even though the child may appear active and alert. In the absence of dry skin, mental sluggishness, and the usual bloating of myxedema, one might suspect a

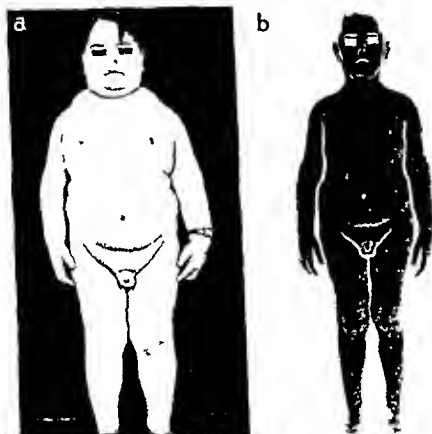


Fig. 299—Myxedema with goiter largely intrathoracic. Age fourteen, height  $47\frac{1}{4}$  inches weight  $94\frac{1}{4}$  pounds. Mentally retarded.

*a*, Before treatment. Grew normally until four or five years of age. One of thirteen children, three others of which had goiter, one with myxedema. Basal metabolic rate  $-36$ , blood cholesterol  $337$  mg per cent. Treated with  $17$  grains of thyroid per week, following which basal metabolic rate rose to  $-2$ , and blood cholesterol dropped to  $172$  mg per cent. Roentgenograms before treatment showed intrathoracic goiter extending to arch of aorta, trachea narrowed. After treatment no signs of intrathoracic extension could be seen. Puberty was beginning and right testis had descended.

*b*, Patient fourteen months later. Three years after treatment height was  $56\frac{1}{4}$  inches weight  $103$  pounds and basal metabolic rate  $-3$ .

pituitary deficient child. The presence of goiter, however, rules out that possibility. Such cases would appear very much like a thyroid deficient child who has been treated a few months with desiccated thyroid. When these cases were first encountered it seemed difficult to correlate the various findings.

Bartels, elsewhere in this symposium, reports two cases in which hyperthyroidism developed in previously thyroid deficient children. These cases have provided a very positive proof that thyroid function can return to or above normal, thus providing an adequate explanation why a child with the stigmata of cretinism shows no demonstrable evidence of thyroid deficiency.

From our experience in treating some of these patients, it would appear that the adenomatous goiter may be the result and not the cause of thyroid deficiency. Histologically, some show in addition to the usual picture of colloid adenomatous goiter, some degree of secondary hyperplasia. Administration of desiccated thyroid may reduce



Fig. 300—Same case as Figure 299. *a*, Bone age four years; *b*, two years after treatment was begun, bone age twelve years.

the size of the goiter if thyroid deficiency is present, at times quite remarkably. This may come about through supplying the body with thyroid hormone, thus lessening the load on that part of the thyroid capable of functioning and in addition causing some inhibition of pituitary thyrotropic activity.

Removal of such a goiter might be followed at least temporarily by greater thyroid hormone deficiency, but also by a greater stimulation to pituitary thyrotropic activity. Hyperplasia and recurrence of goiter could thus take place. This is suggested by Bartels' second case in which not only goiter recurred but also thyroid activity and eventually hyperthyroidism developed. Hertzler stated that he has cured myxedema by total ablation of the thyroid or goiter. In view

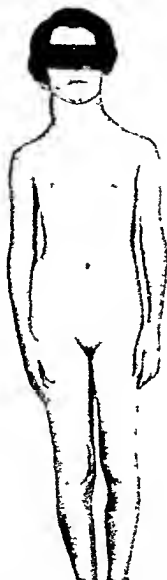


Fig. 301.—Patient aged fourteen years. Large adenomatous goiter, partly intra-thoracic, with retarded growth and sexual development. Duration of goiter twelve years, larger last six to twelve months. Patient mentally alert, height  $56\frac{1}{4}$  inches, weight  $69\frac{1}{2}$  pounds. Bone age ten years, basal metabolic rate  $\pm 0$ , blood cholesterol 160 mg per cent. Roentgenogram revealed deviation of trachea to left above and to right below. Subtotal thyroidectomy performed in 1936. There was postoperative collapse of trachea requiring tracheotomy, convalescence otherwise was uneventful. Pathologic report: multiple colloid adenomatous goiter with secondary hyperplasia. Given desiccated thyroid  $1\frac{1}{4}$  grains daily. Grew  $3\frac{1}{2}$  inches in four years,  $3\frac{1}{2}$  inches more than average for age (Burgess chart). Puberty followed.

This patient revealed no clinical evidence of myxedema. With sudden increase in size of goiter in the previous year there may have been increasing thyroid activity to a normal level when seen. Although good in school, she had just completed seventh grade at age of fourteen. Without operation she might have developed normally, although late for her age.

of our observations and the generally accepted function of the thyroid gland today, this feat is entirely possible if some thyroid tissue is inadvertently or intentionally left behind.

The photographs of two patients with hyperthyroidism occurring in previously thyroid deficient children are shown in the article by Bartels. Three other cases illustrating adenomatous goiter in children are shown in Figures 299 to 302.

Treatment of adenomatous goiter in children should be surgical if no thyroid deficiency exists and if there is substernal extension or



Fig 302—Sister of patient shown in Figure 299. Age twenty years, mentally retarded, height 56½ inches, weight 98 pounds. Normal secondary sex development, catamenia began at age seventeen. At age of twelve she was given thyroid for a short time. Basal metabolic rate was +8, blood cholesterol 160 mg per cent. Radial epiphyses open, phalanges closed (bone age seventeen years). No clinical signs of thyroid deficiency. No significant decrease in size of goiter on thyroid or thyroid plus iodine, but it appeared to increase in size during one year's omission of above treatment. Patient desired operation for cosmetic reasons, which was done. Pathologic report: multiple colloid adenomatous goiter with coincident fetal and embryonal adenoma.

pressure on the trachea. Removal for cosmetic purposes is justified. If thyroid deficiency is present, a trial of desiccated thyroid should be given first.

After surgical removal, the child should be watched for thyroid deficiency and treated. Observations on a thyroid deficient child with goiter operated upon in 1923 are shown in the tabulation. Before operation, the goiter became larger, possibly because of inadequate thyroid treatment. Recurrence of the goiter after operation took place while thyroid had been administered in insufficient amounts. Upon the

resumption of adequate dosage, the orange-sized goiter was reduced to a small, slightly nodular gland. In spite of this, he has attained fairly normal development, is able to earn a living at watch making, but is not of average intelligence.

DATA ON THYROID-DEFICIENT CHILD WITH GOITER

Date	Age, years	Weight pounds	Height inches	BMR	Comment
9/21/23	8	40½		-5	Dull, sleepy, retarded since birth. Obviously under height and weight for age. Has taken a few pills (?thyroid). Goiter developed at 5 yrs of age. Desiccated thyroid begun.
9/30/26	11				Did not take thyroid regularly. On liquid iodine. Started on 0.4 mg thyroxin daily.
10/1/26					Goiter diminished in size but then grew. Thyroxin stopped.
9/24/27		58		-10	Advised again. Large goiter. Growth rate 3 inches per year last 2 yrs. Goiter removed 'Fetal adenoma'.
10/20/28		65		+1	On 0.8 mg thyroxin twice a week.
10/30/29	14	73	55		No thyroxin 3 weeks.
4/30/30		75		-16	No thyroxin 4 months.
7/24/30		78			Neck enlarging. No thyroxin.
11/1/30		76		-23	Signs of myxedema. No thyroxin.
4/21/31		73		+4	On 0.8 mg thyroxin daily. Doing well.
4/26/32		92		+9	0.8 mg twice a week.
4/27/33	18	100	62¼	-9	0.8 mg twice a week. Appears about 14 yrs old.
5/7/37		118		+14	0.8 mg thyroxin twice a week.
6/4/38		128	66¾	-3	Orange size goiter. Circumference of neck 17 inches. Dose increased to 0.8 mg daily.
3/14/39		130	66¾	-9	Visible goiter but smaller. Circumference 14¾ inches.
2/14/45		138	66¾		Taking 0.8 mg thyroxin daily. Fully developed. Works in watch factory. Subnormal mentality. Palpable slightly nodular thyroid.

Recently a patient was seen with recurrence of nodular goiter while taking 2 grains of desiccated thyroid for obesity. One might expect such treatment to have prevented further growth because of (1) providing adequate thyroid for bodily needs and (2) inhibiting thyrotropic activity. The reduction in the size of adenomatous goiter in

patients with myxedema in some cases marked, has been observed in children as well as in adults

#### MYXEDEMA FROM CHRONIC THYROIDITIS AND SPONTANEOUS CESSATION OF PRIMARY HYPERTHYROIDISM

Chronic thyroiditis may produce myxedema and its treatment is the same as that for ordinary myxedema so far as the thyroid deficiency is concerned. Surgical interference is not often necessary except when it is thought malignancy may exist. A hard diffuse gland may exist in a myxedematous individual who has had a previous history of Graves' disease. These cases are rare, and it is probable that some degree of thyroiditis is present.

#### MYXEDEMA FOLLOWING TREATMENT OF HYPERTHYROIDISM

From Iodine—I have recently reported an instance of myxedema resulting from iodine administration in a girl of six<sup>2</sup> (Figs. 303 and 304). It was thought by the patient's physician that a colloid goiter



Fig. 303—*a* Myxedema following use of Lugol's solution in a girl of six; *b*, Six weeks after omission of Lugol's solution (see Fig. 304)

existed, but although the basal metabolic rate at the first examination was  $-7$ , the history suggested the possibility of a mild hyperthyroidism because of failure to gain weight. Furthermore, the gland after iodine was given was enlarged and firm, suggesting an involuted

hyperplastic gland. The basal rate when myxedema was present was  $-25$  and blood cholesterol was  $400$  mg per  $100$  cc. On omission of iodine, the patient's condition returned to normal and remained so. Mild myxedema has also been noted in patients with a mild recurrence of hyperthyroidism who have been given iodine. In fact, iodine given routinely for several months after subtotal thyroidectomy has masked a mild, persistent hyperthyroidism in the days when less radical procedures were carried out.

**From Irradiation**—The hyperplastic gland is susceptible to x-rays, particularly the hyperplastic remnant of recurrent or persistent hyperthyroidism (Fig 305). In our experience in treating the latter, a small group of cases which are prone to persist or recur unless the hyper-

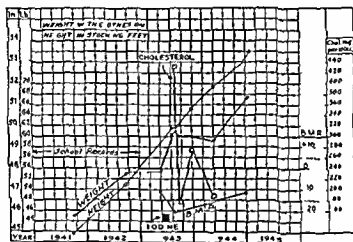


Fig 304—Chart of observations on a girl of six (Fig 303) showing failure to gain weight prior to administration of Lugol's solution. Note cholesterol value of over  $400$  mg per cent and basal metabolic rate of  $-21$  during myxedematous state and subsequent return to normal.

plastic tissue is completely destroyed, myxedema may be produced, in fact, unless it is produced, the effect of x-rays appears limited. Having seen recurrences take place with insufficient dosage, it became our practice to give twelve to eighteen treatments of  $300$  r each. We have rarely seen recurrences even with this dosage. At present thiouracil is being tried in place of x-rays for this type of case. Unless the post-radiation myxedema is not well tolerated, desiccated thyroid is not regularly prescribed. Post-radiation myxedema may also occur after treatment for carcinoma of the thyroid, in which much larger dosages are employed.

**Thiouracil Myxedema**—Myxedema has occurred several times in patients with hyperthyroidism while taking thiouracil. In one case this disappeared in a few weeks when the drug was discontinued (Fig



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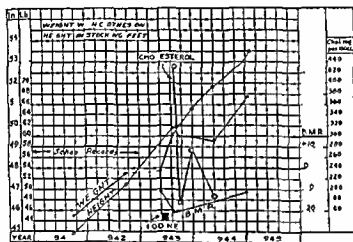


Fig. 304—Chart of observations on a girl of six (Fig. 303) showing failure to gain weight prior to administration of Lugol's solution. Note cholesterol value of over  $400$  mg per cent and basal metabolic rate of  $-21$  during myxedematous state and subsequent return to normal.

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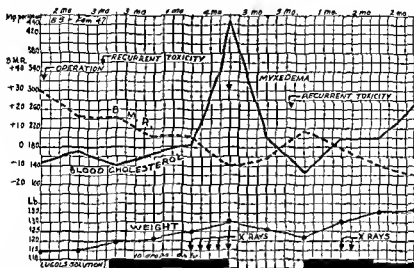


Fig 305—Chart of findings in temporary myxedema produced by x-rays in a case of persistent hyperthyroidism. Radiation dosage, 300 r each treatment.

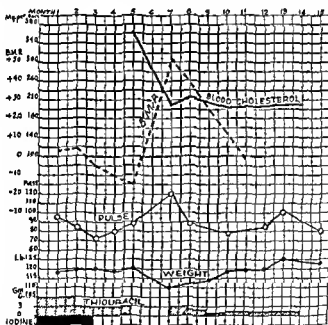


Fig 306—Temporary myxedema following use of thiouracil in a case of recurrent hyperthyroidism controlled with iodine. Repeated observations over several years while on iodine showed the blood cholesterol to average around 200 mg per cent and basal metabolic rates to be normal. Iodine was omitted at about the time it was thought thiouracil would be effective. Note rapid return of hyperthyroidism on omission of thiouracil in the following two months.

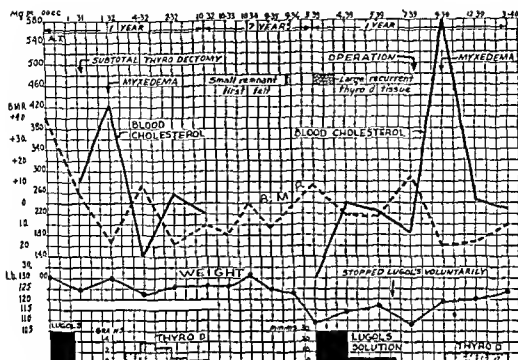


Fig 307—Temporary postoperative myxedema followed by recurrence of goiter and hyperthyroidism. This patient claimed that she could not tolerate Lugol's solution and refused a trial of radiation therapy, hence a conservative reoperation was done.



Fig 308—Myxedema following total ablation of thyroid for heart disease. *a*, Immediately after operation; *b*, three months later, with marked myxedema.

306) One patient so treated went to surgery in a myxedematous state and was very sensitive to preoperative medication—a fact well known about myxedema. We do not know if permanent myxedema can be produced with this drug.



Fig. 309—Man aged fifty six years. Myxedema of twenty six years duration. Angina pectoris, no palpable thyroid. Enlargement and thinning of sella turcica and elevation of right anterior clinoid. Calcification was present to the right of the sella. Roentgenologic diagnosis: intracranial lesion, probably aneurysm of internal carotid artery. Electrocardiogram showed inversion of  $T_1$  and  $T_2$ . Blood cholesterol 391 mg per cent. Unable to tolerate more than 1 grain of thyroid daily without increasing angina. This case may be myxedema with an arteriosclerotic aneurysm pressing on pituitary as a secondary complication. It is unlikely that aneurysm was present at thirty two years of age. The pituitary origin of myxedema in this case is therefore unlikely. Opportunity to study urinary follicular stimulating hormone has not been available but should show normal amounts if myxedema is not of pituitary origin.

**Postoperative Myxedema**—Postoperative myxedema following subtotal thyroidectomy for hyperthyroidism is permanent in only about one half of the group in which it occurs. It may disappear spontane-

ously in a period of a few months to a few years. In event of the latter, thyroid function may swing above the normal to recurrent hyperthyroidism (Fig 307). The occurrence of a low metabolic rate without myxedema after subtotal thyroidectomy is not infrequently seen. In general, thyroid is not particularly helpful, especially if the blood cholesterol is not elevated. It does, however, deserve a trial in some cases. Total ablation produces myxedema which should remain permanent (Fig 308).

**Pituitary Myxedema**—Most of the classical signs and symptoms of myxedema may be present in rare cases of pituitary tumor (Fig 309). Because of an associated adrenal insufficiency in these cases, desiccated thyroid may not be well tolerated; in fact it may be decidedly dangerous. Even if well tolerated, it is less effective than in ordinary or primary myxedema. Skull roentgenograms should be taken in all cases thought to be idiopathic or spontaneous myxedema. In some cretins an enlarged sella has been demonstrated. This, however, does not mean pituitary tumor.

**Spontaneous Myxedema**—The treatment of ordinary or spontaneous myxedema rarely requires more than 2 grains USP, thyroid daily. When the disorder is of long standing or when it occurs in older people it is safer to begin treatment with not more than  $\frac{1}{2}$  to 1 grain daily. Some cannot tolerate even that dose because of angular pain, in which case the dose should be reduced and no attempt to increase it should be made before two months or more. Large doses as given initially in the past should not be administered as fatalities have occurred. The best guide to dosage in the long run is the optimal dose, in other words the amount on which the patient feels the best.

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# HYPERTHYROIDISM DEVELOPING IN A CRETIN

ELMER C. BARTELS

UNTREATED cretinism is characterized by stunted growth, infantile naso orbital development, pallor, and mental retardation. If it is recognized at an early age and adequate treatment with desiccated thyroid is instituted, rapid acceleration of growth takes place and there is loss of the objective manifestations of the disorder. The cerebral defects in congenital cretinism are not entirely overcome unless treatment is begun during the first or second year of life.

The common presence of adenomatous goiters in cretins may cause a spontaneous return of thyroid function in some of these patients and in rare instances clinical thyrotoxicosis. If this occurs, there is an acceleration of growth and loss of the characteristic facial features of cretinism. The occurrence of hyperthyroidism in these cases has been reported among the goitrous cretins of Europe, but no such reports have been found in the English literature. Lerman, in a personal communication, reported having seen a patient ten years of age who had hyperthyroidism and adenomatous goiter and whose past history was suggestive of cretinism.

Two patients with cretinism who developed hyperthyroidism have been observed at the Lahey Clinic, and they are the basis of this report. The fact that only two cases of this type have been observed among 24,000 patients undergoing thyroidectomy indicates the rarity of this combination.

## REPORT OF CASES

CASE I—A girl of fourteen was first seen at the Clinic on April 24, 1944. She was referred because of a goiter which had been present for about ten years. Some two months before, the basal metabolic rate had been determined and reported to be +46. The family history was entirely negative, there being three other children in good physical condition. She was a premature baby and was delivered by forceps. It was noted early that physical development was slow, and at the age of two and a half years she was studied at a hospital where it was found that there was retarded bone and mental development. It was concluded that the retardation was the result of birth injury. She did not walk until she was three years of age. The mother reported that relatives had commented on the pallor of the child and the coarseness of the hair. Rouge was frequently applied to the cheeks to cover up the pallor to avoid comment.

Extremely slow development continued until the age of ten (Fig 310, *a* and *b*). After this age the pallor and dryness of the skin began slowly to subside and growth began to occur. At this time the patient was again studied because of progressive enlargement of the thyroid which had occurred during the previous six months. She was given both Lugol's solution and desiccated thyroid without change in the



Fig 310 (Case I) —*a* Typical features of cretinism age five years  
*b*, Age ten years comparison with other members of family showing retarded growth (patient indicated by arrow)  
*c*, Age fourteen years comparison with other members of family, showing marked change in features

size of the thyroid gland. The basal metabolic rate at that time was  $+12$  and  $+20$ .

During the next four years there was a noticeable acceleration of growth (Fig 310, *c*), the child became more active and she gained some initiative, following which there occurred irritability, excess perspiration, breathlessness and palpitation.



General examination revealed a mentally retarded child who appeared eight years of age instead of fourteen (Fig 311, *a*). The weight was 65 pounds height 51 inches and the pulse rate was 120 and regular. The blood pressure was 104 mm systolic and 60 mm diastolic. The skin was moist. The thyroid gland was considerably enlarged and was nodular in consistency.

The urinalysis was negative. Blood studies showed the hemoglobin to be 14.6 gm, red blood count 5 070 000, white blood count 8 900. Hinton test negative and plasma cholesterol 185 mg per 100 cc. The roentgenogram of the skull was negative. The dental age and bone age

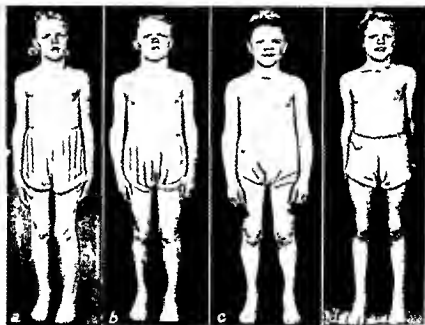


Fig 311 (Case 1)—*a* Phase of active hyperthyroidism, *b*, phase of control with thiothiuracil, *c* phase of postoperative myxedema, *d*, phase of control with desiccated thyroid.

of the hands by roentgenologic examination was twelve years. The basal metabolic rate was +34 per cent.

The diagnosis of hyperthyroidism seemed certain. The history of slow physical and mental development suggested cretinism, and the photograph (Fig 310, *a*) seemed to justify this diagnosis. The characteristic facial features of cretinism—flat and broad bridge of nose, wide set eyes, short underdeveloped nose—are apparent in the photograph. The rapid growth which occurred following the age of ten years—8 inches in four years (Fig 312)—was also additional evidence of cretinism since only in this condition with the development of hyperthyroidism or by treatment with desiccated thyroid could such

rapid growth be expected to occur. The final diagnosis was adenomatous goiter with hyperthyroidism developing in a cretin.

Because the hyperthyroidism was considered moderately severe, the patient was prepared for thyroidectomy with thiouracil. This was given in a daily dose of 0.3 gm for fifty-two days, at which time the basal metabolic rate was  $\pm 0$ . The pulse rate was 88 and the weight 68 pounds. There was marked clinical improvement, as indicated by less stimulation, slight gain in weight and less palpitation. A daily dose

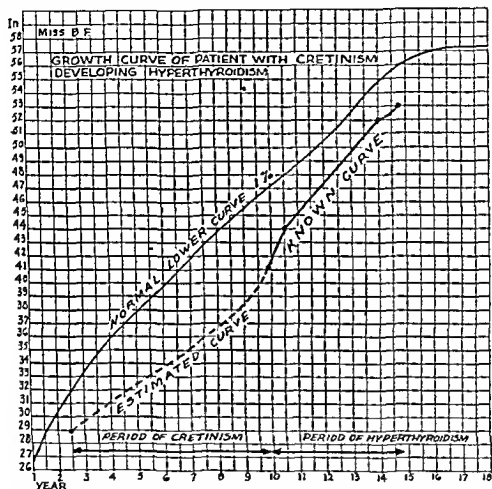


Fig 311 (Case I).—Growth curve of patient compared with that of normal individual

of 0.1 gm of thiouracil was continued for the next month with still further general improvement (Fig 311, *b*). At this time subtotal thyroidectomy was done, with a satisfactory anesthesia course. After operation, laryngeal edema occurred which necessitated a tracheotomy, but convalescence was rapid and she was discharged from the hospital on the fifteenth day. She was given instructions to take  $\frac{1}{2}$  grain of desiccated thyroid a day. The pathologic diagnosis was multiple colloid adenomatous goiter.

One month after discharge from the hospital the patient weighed 67 pounds and the blood cholesterol value was 223 mg per cent. The administration of desiccated thyroid  $\frac{1}{2}$  grain, was continued for two more months and then discontinued. One month later she was seen again at which time she showed the typical changes of myxedema (Fig 311 *c*). The skin was dry, lids puffy, and she complained of coldness. The weight had increased 9 pounds to 76 $\frac{1}{2}$  pounds. The blood cholesterol at this time was 402 mg per cent. Desiccated thyroid  $\frac{1}{2}$  grain was again advised and one month later all evidence of myxedema had subsided (Fig 311 *d*). The weight was 75 pounds and the blood cholesterol was 223 mg per cent. The daily dose of  $\frac{1}{2}$  grain of desiccated thyroid is to be continued indefinitely.



Fig 313 (Case II) —Large adenomatous goiter

CASE II—A boy of eleven years was first seen at the Clinic in December 1931 with the chief complaint being that of a lump in the neck. The mass had been present since birth, and had increased in size during the last year. There had been weight loss of 9 pounds during the past six months. The weight was 51 pounds, and the pulse rate 84 beats per minute. There was slight pallor. A large cystic tumor mass approximately 12 cm in diameter (Fig 313), occupied the right side of the neck. Large veins coursed over the mass which was movable and not tender.

The red blood count was 5,210,000 and white count 7,100. The basal metabolic rate was +12. The blood cholesterol level was 212.

mg per cent. A roentgenogram of the chest was negative. Roentgenograms of the hands showed the epiphyseal development of that of a child five years of age (Fig. 314).

A diagnosis of adenomatous goiter was made. Because of the bone age, as indicated in the roentgenogram, it was concluded that a hypothyroid state had existed and that the basal metabolic rate was normal at the time of examination owing to restoration of thyroid function. He seemed to have normal mental development. A right subtotal thy-



Fig. 314 (Case II) — Bone age of five years in patient aged eleven years.

roidectomy and excision of a cystic mass of the left lobe were carried out, with satisfactory postoperative convalescence. The pathologic report was multiple colloid adenomatous goiter without hyperplasia. The patient was discharged from the hospital with instructions to take 1 gram of thyroid every other day. He continued taking the thyroid for several months and then discontinued it, and was not heard from for eleven years.

In 1942, at the age of twenty-two, the patient again returned to the

Clinic, complaining of nervousness, irritability, fatigue and palpitation of several months duration. There had been progressive enlargement of the neck for the last five or six years. He had been forced to give up work because of his symptoms.

Physical examination revealed the patient to be underdeveloped and with some mental retardation although thyrotoxic. The pulse rate was 84 and the blood pressure 120 mm systolic and 80 mm diastolic. There was a large, irregular, soft adenomatous mass in the thyroid area.

Routine urine and blood tests were normal. The basal metabolic rate was +21 and the blood cholesterol value was 178 mg per cent. Roentgenologic examination of the hands and wrists showed the bones to be fully developed. The roentgenogram of the chest was negative.

A diagnosis was made of recurrent adenomatous goiter with hyperthyroidism and after administration of iodine for nine days, subtotal thyroidectomy was done. The pathologic diagnosis was multiple colloid adenomatous goiter with secondary hyperplasia.

#### SUMMARY

Two cases of adenomatous goiter with hyperthyroidism developing in cretins have been reported. Both patients had had adenomatous goiter since early childhood with hyperthyroidism developing at about the age of ten years. The first patient showed irrefutable evidence of cretinism from birth, with retarded growth and mental change. When the patient was ten growth was markedly accelerated and evidence of thyroid deficiency disappeared with the development of hyperthyroidism. Thyroidectomy was carried out after thiouracil therapy. Postoperative myxedema developed which is under control with desiccated thyroid. The second case, although not showing objective evidence of cretinism, had the bone changes of hypothyroidism. Thyroidectomy was done and eleven years later recurrent hyperthyroidism developed which was again treated by subtotal thyroidectomy.

## CLINICS ON OTHER SUBJECTS

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### THE TECHNIC FOR SUBTOTAL RESECTION OF THE STOMACH FOR CARCINOMA

SAMUEL T. MARSHALL.

VARIOUS methods have been proposed and employed for resection of the stomach for carcinoma since Billroth, in 1885, described his second operative procedure for partial gastric resection. This second operation is known familiarly as the Billroth II operation and consists of closure of the divided end of the duodenum and also of the transected upper end of the stomach, the jejunum being brought anterior to the transverse colon and anastomosed to the most dependent part of the remaining portion of the stomach. Most of these resections of the stomach are essentially some modification of the Billroth II operation. Probably the most widely known type of such a modification is the Polya method of resection of the stomach, which has proved to be a satisfactory method in the hands of many surgeons. Von Eiselsberg, in 1888, first reported the type of resection which is now widely known as the Hofmeister method of resection of the stomach. At the Mayo Clinic for some years now we have employed a method utilizing slight modifications of the technic of the Hofmeister method of anastomosis, and in general this method has proved of value at least in our hands, and is an operative technical procedure which can be employed readily in most cases.

#### IMPORTANCE OF TOTAL REMOVAL OF LYMPH NODES

The technic of subtotal resection of the stomach for carcinoma is essentially the same as that for partial resection of the stomach for peptic ulcer whether gastric or duodenal. However, the procedure must be modified somewhat because of certain technical considerations and because of the necessity of doing a somewhat more extensive excision for malignant tumor. Obviously, any attempt to plan for the surgical removal of a carcinoma means that the growth must be completely removed along with all the adjacent lymph nodes to which the initial growth may early metastasize. In other words, as radical a partial gastrectomy must be done as possible and, if necessary, even a complete or total gastrectomy must be performed in order to remove all tumor. The technic of total gastrectomy has been described in a

previous publication from this Clinic.<sup>2</sup> Great attention should be paid to the removal of the lymphatic nodes of both curvatures. We believe it is not only wise but of value to remove all the great omentum. This can be done easily as advocated by Ogilvie. The detachment of the omentum (Fig. 315) from the colon is extremely simple and actually requires less ligation of vessels than division and ligation of the gastrocolic omentum.

Cuneo describes three main groups of perigastric lymph nodes: the first group consisting of the nodes of the cardiac and lesser curvature. These nodes lie in front and behind the vertical portion of the cardiac orifice and follow the lesser curvature of the stomach wall and the course of the coronary artery. The second is the hepatic or pyloric chain which drains the lower two thirds of the greater curvature and the pyloric area. The third is the splenic group, which is along the splenic artery from the stomach to the hilus of the spleen; these glands drain the fundus of the stomach. It is for this reason that splenectomy should be combined with resection of the stomach in the presence of extensive involvement of this group of glands. In planning any resection of the stomach for carcinoma it is absolutely imperative to be aware of the gland distribution and very carefully to dissect and remove all of these lymph nodes along with the resected portion of the stomach containing the carcinoma. As Ewing has pointed out, when a sufficient number of nodes are carefully examined after resection for carcinoma, few cases will be found to be free from invasion and the retropyloric nodes and those of the lesser curvature are more often involved than the other groups. Furthermore, nodes along the greater curvature commonly are present in the greater omentum. It is not only necessary but a very practical procedure to remove the omentum as a whole, and this we routinely do.

#### OPERATIVE STEPS

**Anesthesia**—At the Lahey Clinic all gastric resections, complete or partial, are now undertaken under fractional spinal anesthesia, using the method proposed and developed by Lemmon. By this method complete relaxation can be maintained or restored by minimal doses of the anesthetic agent, and this has proved valuable in reducing shock especially in elderly people, inasmuch as small initial doses can be given at the start of the operation and renewed whenever found to be necessary to prolong anesthesia and relaxation.

**Incision**—The operation is performed through a left rectus incision extending from the left costal margin to the level of the umbilicus or below, the incision being made of sufficient length to allow any intra

abdominal surgery to be carried out readily. Upon opening the abdomen a complete survey must be made to determine the extent of the primary growth in the stomach and the degree of lymph node involvement along both curvatures and in the omentum. The peritoneum must be examined carefully for metastatic deposits and this examination must include the pouch of Douglas. The liver should be examined for metastatic nodules and in the presence of liver metastases or evidence of other distant metastases, resection of the stomach will prove of no value and should not be done. If upon examination the malignancy of the stomach proves to be operable, a partial, sufficiently wide gastrectomy should be carried out.

**Exploration**—It is important before beginning any extensive mobilization of the stomach to ascertain if the gastric lesion has extended to and involved the pancreas, likewise, the extent of involvement of the lymph nodes around the celiac axis should be determined. The pancreas and the celiac axis may be readily visualized by detaching the omentum from the transverse colon. This allows the omentum to be retracted upward and opens the lesser omental cavity (Fig. 316), the stomach may be retracted in a similar fashion, exposing the pancreas and also the celiac axis, with the origin and the course of the left gastric or coronary artery readily visualized.

If resection of the stomach is not possible because of extension of the carcinoma to the pancreas or if lymph node involvement around the celiac axis is too widespread to permit complete removal of this group of nodes, the stomach then may be laid back in its normal position and the omentum placed over the transverse colon without suture and the operation abandoned without any risk to the patient incurred by detachment of the omentum from the transverse colon.

**Detachment of the Omentum and Mobilization of the Greater Curvature of the Stomach**—As already stated, the omentum can be separated very easily from the transverse colon (Fig. 315) and removed *en bloc* with the resected portion of the stomach without the necessity of ligating more than two or three small bleeders. This more completely than any other method lays open the lesser omental cavity which not only permits a more careful evaluation of the extent of the tumor but also facilitates the operation of partial resection.

The two layers of the peritoneum (Fig. 315) which enclose the anterior and posterior surfaces of the stomach fuse along the greater curvature of the stomach and along the first portion of the duodenum. These layers enclose the gastro-epiploic vessels along the greater curvature. After fusion, the two layers pass down anterior to the colon where they descend some distance to form the greater omentum and



then turn posteriorly and upward as far as the transverse colon where they separate and envelop the transverse colon between the anterior and posterior peritoneal layers. The anterior layer continues up to the pancreas, forming the posterior peritoneal layer of the lesser peritoneal cavity. Accordingly, then, to detach the omentum and open the lesser omental cavity, the omentum is grasped firmly by the assistant and held and brought forward with slight tension on the omentum. An incision can then be made through the posterior layer of the per-

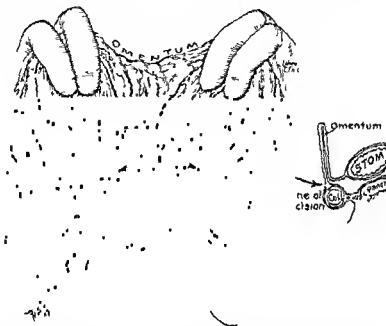


Fig 315—Detachment of the omentum from the colon. Traction is put on omentum and detachment is obtained by incision of the posterior peritoneal layer along the edge of the transverse colon. The lesser omental cavity is easily opened by this maneuver.

*Insert.* The two peritoneal layers are shown enveloping the stomach and the anatomical relation of the omentum to the stomach, colon and lesser omental cavity also is shown.

neum at the border of the colon, carrying the incision along the edge of the transverse colon. This can be done with but little hemorrhage. The colon is then carefully brushed from the omentum by gauze sponge which permits opening readily into the lesser omental cavity. Or one or two vessels may have to be ligated at either end of the attachment of the omentum to the transverse colon. The omentum may then be removed completely, with the part of the stomach to be resected. The absence of extension of the malignancy to the pancreas and the absence of conglomerate fixed lymph nodes about the cel-

axis will then permit the operator to proceed with the resection of the involved portion of the stomach.

**Mobilization of the Lesser Curvature and Duodenum.**—With the entire greater curvature of the stomach mobilized by this detachment of the omentum, the dissection is carried down along the inferior border of the first part of the duodenum, thus completing mobilization of

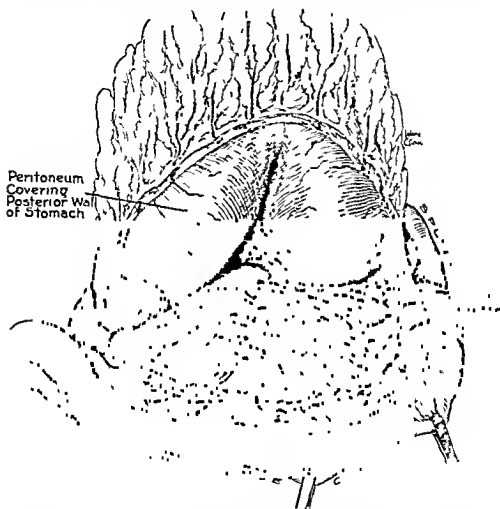


Fig. 316—The omentum is separated from the transverse colon. The stomach with its attached omentum is turned upward, thus opening into the lesser omental cavity. This exposes the pancreas and permits visualization of the middle colic artery and splenic vessels.

the greater curvature of the stomach together with its attached omentum and the first portion of the duodenum (Fig. 316). The lesser curvature of the stomach may then be mobilized by making an opening through the avascular portion of the gastrohepatic omentum. This is a thin, filmy structure along the lesser curvature between the right gastric artery and the coronary artery. A gauze sponge may be placed

around the stomach to permit elevation of the stomach. The right gastric artery may then be exposed easily, divided and ligated (Fig 317). Mobilization of the first portion of the duodenum along its superior border can be completed easily. All glands in this area, which include the retropyloric and the subpyloric, should be removed with the stomach.

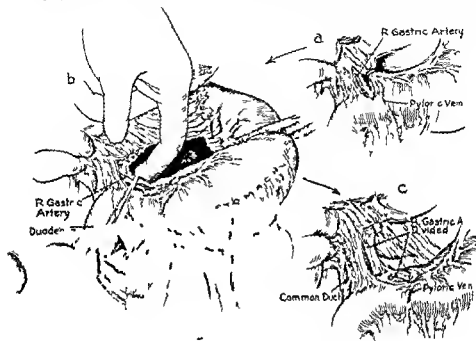


Fig 317—*a* Greater curvature of the stomach and inferior border of the posterior part of the duodenum have been completely mobilized. The thin avascular gastrohepatic omentum above the lesser curvature has been opened and a gauze sponge placed around the stomach to provide for traction and elevation of the stomach.

*b* The right gastric artery and vein are exposed, clamped, divided, and ligated.

*c*, The gastrohepatic omentum is ligated and the lesser curvature cleared. The upper border of the first part of the duodenum is mobilized. The duodenum is now ready for division.

**Division and Closure of the Duodenum**—The duodenum is now divided between clamps about an inch beyond the pylorus or well beyond the tumor. The stomach may be retracted upward and to the left side of the abdomen.

Closure of the duodenum is obtained in one of two ways (Fig 318). The end of the duodenum is grasped above the crushing clamp by Allis clamps, the crushing clamp removed, and a first row of sutures consisting of continuous suture of fine chromic catgut is inserted. In

version and reinforcement of the duodenal stump is obtained with one or two rows of interrupted black silk. The closed end of the duodenum may then be buttressed against the head of the pancreas. Should it be necessary to remove a larger segment of the duodenum, the duodenal stump may be closed with a Connell stitch without employing a crushing clamp, thus avoiding sacrifice of any of the duo-

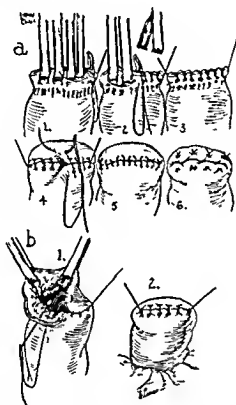


Fig 318.—Closure of the divided end of the duodenum. *a*, Allis clamps are applied and the crushing clamp has been removed. The first suture consists of a continuous stitch of chromic catgut. Inversion and reinforcement are obtained by insertion of interrupted stitches of black silk.

*b*, If the duodenum is shortened by radical removal of the duodenum with the gastric tumor, no crushing clamp is applied on the distal end. The open edges of duodenum are grasped with Allis forceps and closure is obtained by inverting the edges with a Connell stitch. This likewise is reinforced with interrupted silk sutures.

denum which might result in shortening of the stump and subsequent difficult inversion of the stump. Great care must be employed in closing the duodenal stump to prevent the possible development of a duodenal fistula, with adequate closure this should never occur. Traction is then made upon the stomach upward and to the left. This maneuver permits easy exposure of the celiac axis and the origin of

the left gastric artery or coronary artery is easily identified (Fig 319). The lymph nodes in this region are stripped up from the celiac axis and the left gastric artery is divided at its origin from the celiac axis. Mobilization of the stomach is continued on both curvatures well beyond the tumor, great care being taken to remove all fatty and areolar tissue from either border of the stomach in order to permit

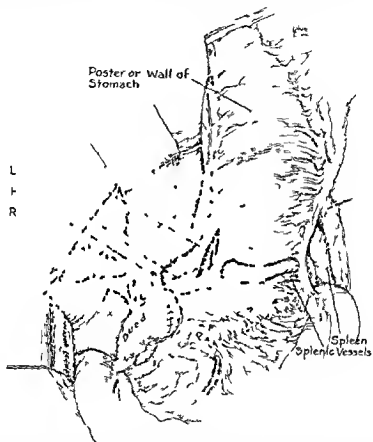


Fig 319—The duodenum has been divided and closed by inversion with cat gut and layered sutures of silk. The stomach is lifted upward and to the left. Note exposure of the left gastric vessels. The left gastric vessels may now be divided and ligated, stripping all nodes from about the celiac axis.

safe inversion of the upper half of the transected end of the stomach and to permit accurate and safe approximation of the jejunum in establishing the gastrojejunal stoma.

The stomach is now thoroughly mobilized well above the site of the carcinoma, a wide margin of normal gastric tissue should intervene between the line of transection and the tumor.

**Section of the Stomach**—The von Petz clamp is now placed across the stomach at a point well above the carcinoma and the clips are inserted by the machine (Fig 320). The stomach is divided between the double row of silver clips by actual cautery. The malignant tumor with the omentum and all the nodes is then removed *en bloc*.

**Gastrojejunal Anastomosis**—We may now proceed with the establishment of the gastrojejunal anastomosis. A long loop of jejunum is brought anterior to the colon with the proximal loop of the jejunum

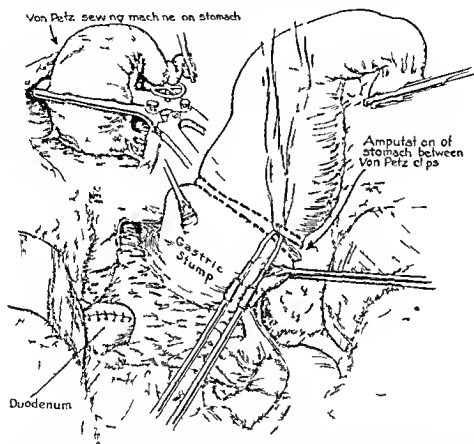


Fig 320—Transection of stomach above tumor. Note application of von Petz clamp. A double row of clips is inserted and division of the stomach is made by cautery between the two rows of clips.

being placed at the greater curvature of the gastric stump. A gastrojejunal anastomosis is done after the manner of Hofmeister. The upper half or lesser curvature half of the transected end of the stomach, with clips in place, is inverted with a row of chromic catgut, reinforced with interrupted mattress sutures of silk (Fig 321). The jejunum is then sutured with interrupted sutures of black silk to the lower half of the transected end of the stomach where the stomal orifice is to be established. This forms the first posterior suture layer. Incision is made

into the jejunal wall opening into the lumen and the stomach is likewise opened by cutting away the row of clips corresponding to the

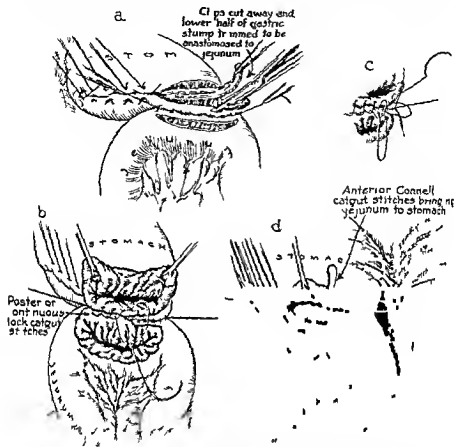


Fig 321—Restoration of gastrojejunal continuity *a* The lesser curvature half of the divided end of the stomach has been inverted with clips in place by a continuous suture of chromic catgut which is reinforced with interrupted silk sutures. The jejunum is attached to the gastric stump by a row of interrupted silk sutures. This forms the first posterior row of sutures. Incision is made into the jejunum and the stomach is opened into by cutting away the row of clips.

*b* The second posterior suture consists of a continuous interlocking catgut suture which approximates the viscera.

*c* The manner in which the catgut stitch is placed at the end of the gastrojejunal anastomosis. It is then continued as the Connell stitch on the anterior suture row.

*d* The second posterior suture (*b*) is continued anteriorly as a Connell stitch to form the first anterior row of suture material.

length of the incision into the jejunum. A posterior row of continuous interlocking catgut is used to form the second posterior layer of stitches. This catgut suture is continued as a Connell suture to form

the first anterior row of sutures thus closing the rent made into the stomach and jejunum and forming the stomal orifice between the end of the gastric stump and the lateral wall of the jejunum. The anterior suture line is then reinforced with a second layer of interrupted black silk sutures (Fig. 322). A portion of the jejunum just distal to the stomal orifice is buttressed against the closed end of the stomach.

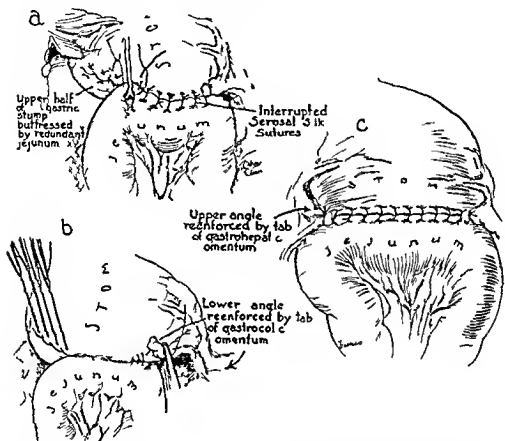


Fig. 322—*a* Completion of the gastrojejunostomy. Interrupted black silk sutures form the second and reinforcing anterior suture line. The distal unopened jejunum is buttressed against the inverted end of the stomach.

*b* The angles of the anastomosis are reinforced by tying in a tab of omentum at either angle.

thus reinforcing the suture line. The angles are further reinforced by tying in an omental tag on either curvature of the stomach at the ends of the gastrojejunostomy. This completes the gastrojejunostomy after resection of the stomach for cancer.

#### COMMENT

This modification of the Hofmeister method has proved to be a most satisfactory method of restoration of gastrointestinal continuity.



We have employed it routinely in all of our partial resections for carcinoma

It is advantageous to place the proximal loop at the greater curvature and to make the anastomosis anterior to the colon. We have not employed an enteroenterostomy between the proximal and distal loops of the jejunum nor have we found it to be necessary or desirable. There has been no difficulty with obstruction arising in the anterior type of anastomosis with this type of restoration of gastrointestinal continuity. The abdominal wall is then closed in layers with chromic catgut. The suture line is reinforced with numerous retention sutures of heavy silk and the skin is approximated with interrupted sutures of fine black silk.

This modification of the Hofmeister method of restoration of gastrointestinal continuity after resection of the stomach has proved of undoubted value in our hands and by this method we have been able to reduce the mortality to a very satisfactory figure. For the last few years the mortality following partial resection of the stomach for carcinoma when this method was employed has been approximately 6 per cent. It is our belief that removal of the omentum facilitates mobilization of the stomach and permits more extensive removal of glands and a more accurate evaluation of the operability in cases of malignancy of the stomach.

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# THE MANAGEMENT OF THE CERVICAL RIB SYNDROME

RALPH ADAMS

THE cervical rib syndrome is a clinical entity characterized by signs of neurologic or vascular disturbances in the neck and upper extremity, and caused by abnormal pressure upon the nerves or blood vessels at the base of the neck.<sup>1-5</sup>

The facts that the symptomatology produced by a cervical rib is variable, that a large majority of cervical ribs produce no symptoms, that bilateral cervical ribs often are accompanied by unilateral symptoms only, that symptoms synonymous with cervical rib syndrome are frequently encountered without a demonstrable cervical rib (scalenus anticus syndrome) have contributed to the difficulties of diagnosis and prompt selection of proper therapy in this condition. We have had twenty-four patients in the past fifteen years who required surgical treatment to relieve their symptoms, and it is upon that group of cases that this report is based. The variability of the presenting complaint is illustrated by the finding that four were treated by the orthopedic service, six by the surgical service, and fourteen by the neurosurgical service. Not included here is a group of thirty-one cases with the typical scalenus anticus syndrome unaccompanied by a cervical rib.

## ANATOMY

An intimate knowledge of the anatomical relationships of the bones, muscles, blood vessels and nerves in the lower cervical region is essential to understanding the pressure phenomena which account for the symptoms produced by a cervical rib, or to carrying out a safely conducted operation for relief of a patient.

The scalenus medius muscle originates from the posterior tubercles near the tips of the transverse processes of the second, third, fourth, fifth, sixth and seventh cervical vertebrae and descends closely approximated to the vertebral column to insert broadly into the upper surface of the first rib behind the subclavian groove (Fig. 323). The scalenus anticus arises similarly except from the anterior tubercles from the third to the sixth cervical vertebrae, and is attached by a tendon to the scapula tubercle in front of the subclavian groove. The cervical nerves from the fourth downward, thereby including all the nerves which contribute to formation of the brachial plexus except the eighth cervical and first thoracic, must pass through the narrow

slit between the scalene bundles equal in thickness only to that of the transverse process tips as they emerge from the spinal canal. As they pass downward to form the major components of the brachial plexus they lie between the bellies of the scalene muscles. Slight alteration of these relationships may produce pressure on the large sixth and seventh

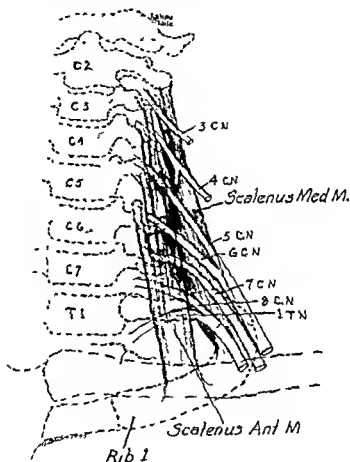


Fig 424—Anatomical drawing of bones, muscles and nerves

cervical nerves and cause symptoms. Among the possibilities are faulty posture, arthritic spurs, spasm of the scalenus anticus, or a rib bud off the fifth or sixth transverse processes. The eighth cervical and first thoracic nerves, mainly distributed peripherally to the medial side of the arm, forearm and hand, are situated too low to suffer from compression between the scalene muscle bellies. However, they unite just above the rigid first rib and behind the fixed subclavian artery, anterior

to which is the taut anterior scalenus tendon, and are particularly vulnerable to pressure from a long seventh transverse process or seventh cervical rib. In like manner, such abnormal bone as it protrudes forward beneath the scalenus medius, and sometimes attached by a fibrous band or actual articulation to the first rib, may compress the subclavian artery against the anterior scalenus.

### PATHOLOGY

In order to achieve greater clarity than is possible in printed photographs of roentgenograms, tracings of the abnormal bony anatomy seen

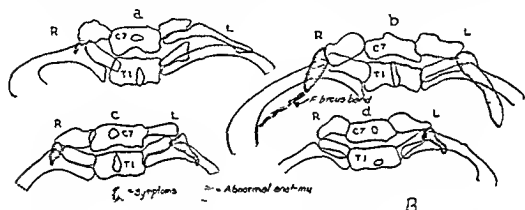


Fig 324—*a*, Right cervical rib with mass, articulation with first rib, long left seventh cervical transverse process. There were no symptoms. Cervical rib was removed to prevent aneurysm.

*b*, Bilateral cervical ribs with long articulation to large tubercle at first rib on left. Symptoms were on left side only and were relieved by resection of the left cervical rib only, without scalenotomy.

*c*, Bilateral palpable cervical ribs. There was pain on the right side only. Pseudo-articulation to first rib on right. Relieved by right scalenotomy and cervical rib resection.

*d*, Left palpable cervical rib with symptoms, relieved by scalenotomy and resection of cervical rib.

on the roentgenograms of cases illustrating typical variations have been made and are reproduced (Figs. 324, 325 and 326). In all cases, the side of symptomatic involvement is indicated by shading. It may be noted that some of the bilateral cervical ribs are as large on the symptom-free side as on the painful side.

### DIAGNOSIS

In this group, the youngest patient was eleven, the eldest fifty-six, the mean age twenty-three, but a large majority were between the ages of twenty and thirty years. There were three males and twenty-one females. In only two was trauma suspected. On the other hand,

Aynesworth emphasized that traumatism was an etiologic factor in 80 per cent of his twenty cases. One of our patients had lost 15 pounds

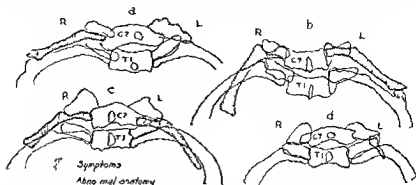


Fig. 325—*a*, Bilateral cervical ribs palpable only on left. Fibrous articulation to left first rib. Pain and numbness on left side. Relieved by left scalenotomy and resection of cervical rib.

*b*, Bilateral cervical ribs but symptoms (pain and atrophy of hand muscles) present on right side only, the side with the shorter cervical rib. Pain was relieved but atrophy persisted. Right scalenotomy and excision of tip of cervical rib were carried out. A fibrous band from the cervical rib to the first rib was compressing artery and medial cord of plexus.

*c*, Bilateral cervical ribs. Mild symptoms on right side for five months. Acute pain on right following gynecologic operation in Trendelenburg position. Relieved by scalenotomy only.

*d*, Left cervical rib with shoulder pain for one year. There was a palpable mass. The patient had lost 15 pounds in weight. There was a tumor in the left lower lung. Carcinoma of lung with cervical metastases was first suspected. There was no metastasis on neck exploration. The mass was a palpable cervical rib. Relieved by scalenotomy and excision of cervical rib. Lung tumor was excised and proved to be a tuberculoma.



Fig. 326—*a*, Bilateral symptoms from bilateral cervical ribs. Relieved by scalenotomy and resection of cervical rib on left and scalenotomy only on right.

*b*, Bilateral cervical ribs and symptoms. Bilateral scalenotomy with excision of a fibrous band from cervical rib to first rib on right side only. Symptoms were relieved.

in weight in the year preceding symptoms. In several the posture was noticeably poor. For most of the cases, however, one cannot assign a reason for the sagging of the shoulder girdle or excessive elevation

of the sternum and first rib which caused pinching of the brachial plexus or subclavian artery between the cervical rib and scalenus anticus muscle. Perhaps actual growth of the cervical rib has been a cause, although it would be unlikely beyond twenty years. In one patient a gynecologic operation in Trendelenburg position may have precipitated the syndrome by pressure from shoulder braces during the operation. Pommerenke and Risteen have reported four similar cases. The subclavian vein is rarely involved, but one of our patients had venous congestion which promptly cleared after operation.

Once the syndrome is established, its vicious or cyclical nature is well recognized, but the essential pathologic process is that of pressure secondary to disturbed anatomical relationships.

### SYMPTOMS AND SIGNS

The symptoms are in some cases acute, direct and unmistakable, in others bizarre and vague. Jelsom's classification of symptoms has proved useful. In Table I are listed the symptoms encountered in the twenty-four cases. It is helpful to remember that one or another symptom complex will predominate, depending upon whether the focus of pressure is high or low in the neck, and whether vascular, somatic or sympathetic nerve compression is the principal factor. Swank and Simone have stressed the variable effects of inferior versus superior types of compression.

Pain of some degree occurred in all except one patient. That patient had a large, palpable cervical rib over which an enlarged subclavian artery coursed, and removal of the rib was thought wise to reduce the likelihood of an aneurysm forming. The pain was described as dull aching by sixteen patients and dull deep by four patients. There was a sharp stabbing pain in one patient. Numbness was the second most common complaint (thirteen patients) and was often intermittent. Pain, numbness, or a dull ache was complained of in all the peripheral distribution of the brachial plexus. Almost everyone is familiar with the pain, numbness, paresthesia, atrophy, cyanosis, reduced radial pulse that may occur in the extremity proper. Less commonly appreciated is the fact that pain may also be referred to the scapula, the anterior chest wall, the neck, the cervical spine and the ear. The location of pain was arm, ten patients, forearm and hand, ten, neck, nine, and chest wall, five. Many of these patients had a typical body attitude, with elevation of the shoulder, being careful not to abduct the arm or turn the head suddenly toward the painful side. Weight bearing, and sweeping, or repeated rotary movements of the arm of any sort may be especially aggravating.

TABLE 1—SYMPTOMS IN TWENTY-FOUR CASES

*Incidence*

Average duration	38 mos (3½ yrs)
Shortest	5 "
Longest	192 " (16 yrs)
Mean	24 " (2 yrs)
Average age	27 yrs
Youngest	11 "
Oldest	56 "
Mean	23 "
Sex	
Male	3
Female	21

*Predisposing Causes*

Traumatic	
Falls or strains	3
Gynecologic operation	1
Nontraumatic	
Spontaneous onset	18
Loss in weight	2

*Primary Symptoms*

Palpable mass	12
Tenderness over anterior scalene	10
Pain	23
Numbness	13
Tingling	3
Change in pulse	9
Blood pressure difference	2
Remission of symptoms	2
Limited abduction of arm	4
Venous obstruction	1

*Secondary Symptoms*

Analgesia	1
Weakness	10
Referred pain	2
Atrophy	6
Cyanosis	3
Temperature changes	3
Tremors	2
Hyperhidrosis	2
Hyperesthesia	4

*Type of Pain*

Sharp stabbing	1
Dull, deep	4
Dull aching	16
Gripping	1
Burning	1
No pain	1

*Location of Pain*

Neck	9
Arm	10

Shoulder	4
Forearm and hand	10
Chest wall	5
Scapula	4
Face or ear	3
Response favorable to procaine block (recurrence after nine months)	1

A palpable mass was found in the lower neck in twelve cases. The anterior scalene was tender to palpation in ten. There was noticeable atrophy of muscles in six. This was most commonly observed in the intrinsic muscles of the hand which are supplied by the ulnar nerve, arising off the medial cord of the plexus (eighth cervical and first thoracic) and the nerve roots most frequently compressed.

Differential blood pressure readings were not recorded in our series. There was hemilateral reduction of radial pulse in nine cases. Signs of vasospasm, sweating, intermittent pallor, coldness were encountered in only two cases. There were two cases with signs of sympathetic nerve irritation sufficient to indicate sympathectomy as a part of the operative procedure. One patient had relief for several months after procaine injection of the scalenus anticus muscle, and operation for recurrence gave permanent relief. We have not routinely used procaine block as a diagnostic test. All of the cases had a cervical rib demonstrable by roentgenography. In sixteen instances the cervical ribs were bilateral, but only three of these patients had bilateral symptoms. Scalenotomy alone was used as the operative procedure for relief of symptoms in eight cases. Although the cervical rib was left in situ, seven of these eight obtained relief and only one is included in the group of five who had incomplete relief. The cases prove that scalenotomy alone without removal of the rib is often sufficient to relieve the patient. We have considered scalenotomy alone an adequate operation, however, only when it obviously accomplished satisfactory decompression of the nerve roots or subclavian vessels. Whenever there was displacement or impingement of bone upon these structures (fourteen cases), removal of the rib also has been done to increase the likelihood of relief. Finally, subclavian distortion (two cases<sup>8</sup>) or actual aneurysm (one case) secondary to pressure from a cervical rib against the vessels we now believe to be an indication that the rib should be removed in addition to division of the scalenus anticus.

#### DIFFERENTIAL DIAGNOSIS

If the foregoing symptoms and signs are presented with a cervical rib or abnormally long transverse process either palpable or demonstrable by roentgenogram, ordinarily there should be little difficulty in



diagnosis. The scalenus anticus syndrome without a cervical rib is almost identical clinically. Donald and Morton have suggested that one name be used for both conditions. Tenderness on pressure over the anterior scalenus and relief by procaine injection may occasionally be of aid in distinguishing between this syndrome and toxic neuritis or cervical arthritis. Raynaud's disease rarely occurs unilaterally, even

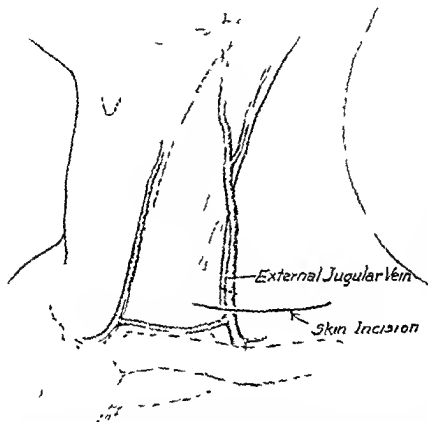


Fig. 327—An incision 5 to 6 cm. in length is made 2 cm. above and roughly parallel to the clavicle. The medial end lies over the lateral third of the clavicular origin of the sternocleidomastoid muscle.

tends to be quadrilateral in its vasospastic manifestations, and is followed by a characteristic response on exposure of the extremity to cold. A ruptured supraspinatus tendon or subacromial bursitis produces tenderness and perhaps a palpable mass at the point of the shoulder or over the humerus rather than over the anterior scalene, and is accompanied by vascular or neurologic changes in the extremity.

Unless the symptoms and signs are marked, the rib very large

danger of serious circulatory deficiency imminent, or the bone obviously grown into the brachial plexus, a trial of conservative therapy is justifiable. Reichert thus relieved sixty of seventy-four patients with symptoms of scalenus anticus syndrome. It should be designed to relieve pain, break the vicious cycle of irritation-pain-irritation, and relax the scalene muscles. Obviously, with a cervical rib present as a fixed permanent jaw of the constricting mechanism, the only hope of

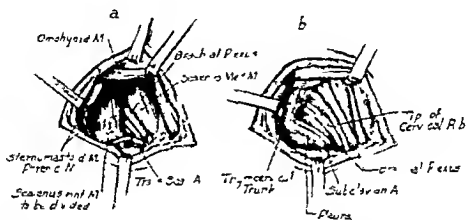


Fig 328—*a*, The platysma, external jugular vein and superficial cervical fascia are divided and the wound margins retracted. The lateral third of the clavicular origin of the sternocleidomastoid muscle is retracted medially, the suprclavicular fat pad which overlies the scalenus anticus separated by blunt dissection, and the inferior belly of the omohyoideus retracted upward. The deep cervical fascia is incised, the phrenic nerve mobilized from the anterior surface of the scalenus anticus muscles along which it courses obliquely downward from the lateral to the medial side of the muscle. The phrenic nerve and internal jugular vein are retracted medially.

*b*, The scalenus anticus muscle in its tendinous portion is dissected free of the important adjacent structures and divided. These are: medially, the superior surface of the subclavian vein; anteriorly, the lateral surface of the internal jugular vein; posteriorly, the apex of the pleura and brachial plexus; laterally, the subclavian artery. Unless the transection is attempted too close to the clavicle, the thoracic duct is not endangered. It is sometimes necessary to divide the transverse scapular artery which crosses the tendon anteriorly to facilitate exposure. The cervical rib is resected from between the brachial plexus roots. The wound is closed in layers.

success with conservative therapy lies in relaxing the scalenus muscle which forms the other jaw. Once relaxed and the cycle of sequence interrupted, relief may last for quite a while. A period of bed rest, sleeping on the back with the head flexed and the shoulders held forward by pillows, support of the shoulder by an arm sling when ambulatory, posture training, physical therapy to develop the trapezius muscle, and procaine injection of the scalenus anticus, are among the nonsurgical measures sometimes helpful.

## OPERATIVE TREATMENT

The operative technic is described in Figures 327 and 328 illustrated for the left side. Anesthesia is by inhalation or regional infiltration. The patient lies upon his back, with the head rotated far to the right and a thyroid bar under the shoulders.

TABLE 2—OPERATIVE STATISTICS

The twenty four operated cases had a cervical rib on

Left side only	4
Right side only	4
Both sides	16
Total	24

Symptoms were produced by

Unilateral left cervical rib	4
Unilateral right cervical rib	3
Unilateral right cervical rib with no symptoms*	1
Bilateral cervical ribs	
Left side only	8
Right side only	5
Both sides	3
Total	24

Operation was performed

Left side only	4
Right side only	4
For bilateral ribs	
Left side only	7
Right side only	5
Both sides†	4
Total	24

\* Operated for large rib mass for fear of aneurysm

† One case in 1935 had prophylactic operation on second side

*Type of Operation*

	Left	Right	Bilateral
Excision cervical rib only	2		1
Scalenotomy only	3	5	
Excision cervical rib and scalenotomy	5	3	
Plus division of fascial band	1	3	
Plus disarticulation from first rib	1	1	
Scalenotomy and sympathectomy	1		
Plus excision of aneurysm	1		

One patient had different operations on two sides—1 extra operation

Two patients had different operations on two sides—2 extra operations

*Results*

Complete immediate relief	14
Complete relief within 3 mos	4
Incomplete relief	5
No preoperative complaints (impending aneurysm)	1
Total	24

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# THE ROLE OF THE NEUROSURGEON IN THE TREATMENT OF PAIN

GILBERT HORRAX

INTRACTABLE pain occurring in various areas throughout the body and due to a great variety of underlying conditions is the complaint of a large number of patients who are referred to neurosurgeons in the hope that some type of operation upon the nerves or the nervous system may give either permanent relief or at least a considerable period of alleviation without the use of habit forming drugs. It is not the purpose of this communication to take up in detail every conceivable condition which comes within this category, but rather to review some of the most usual conditions and to indicate briefly what may be accomplished for them. For this purpose it would seem best to consider the regions of the body under the following headings (1) the head and face, (2) the neck, shoulders and arms, (3) the trunk, and (4) the pelvis and legs.

## 1. THE HEAD AND FACE

*Headache* of course is the commonest type of pain in this area, and after elimination of the various types of headache due to nonsurgical disorders, there are such conditions as *brain tumor*, *brain abscess*, *subdural hematoma*, *increased intracranial pressure without tumor*, *chronic or subacute arachnoiditis*, which must be considered differentially and the appropriate treatment applied. In many persons suffering from one of these conditions the history and neurologic findings will accomplish the diagnosis, but in many doubtful cases recourse must be had to an air injection of the cerebral ventricles—by direct taps when increased intracranial pressure exists or by spinal encephalography when the pressure is normal. In the case of brain tumors, complete removal when possible is the treatment of choice and in about 50 per cent of tumors such removal has been found feasible. However, in many instances radical partial removal and decompression may be all that can be accomplished. Brain abscesses should be drained or in some instances extirpated and followed by injections of penicillin. Subdural hematomas as a rule can be evacuated through simple small trephine openings these being placed over each parietal region in the case of chronic hematomas, or in the temporal regions for the acute or subacute type. Increased intracranial pressure without tumor, the so called *chronic arachnoiditis*, is usually diagnosed by finding normal ventricles in a patient who has headaches and choked disks, but no localizing phe-

nomena. A simple subtemporal decompression is sufficient to alleviate this condition in almost every instance. Another type of headache is that which occurs after *head injury*. When persistent, the best form of treatment for this condition is an oxygen or air encephalogram, which may have to be repeated. Such headaches are relieved by an air insufflation in probably at least 50 per cent of the cases.

When one considers other types of pain occurring in the head, true *trigeminal* or *trifacial neuralgia* (*tic douloureux*) is by far the most frequent condition seen by the neurosurgeon. In most instances the diagnosis is simple. The patient's own description of paroxysmal bouts of pain referred to one or more areas supplied by the trigeminal nerve is usually sufficient. These pains, which come on abruptly and end in the same way, with usually an entirely painless interim between such attacks, are initiated by such things as talking, eating, swallowing, touching the face lightly or even by a current of air striking the face. Often there is a single area in some portion of the face which when touched will set off a paroxysm. This is known as the 'trigger point'. In the early and mild neuralgias conservative medicinal treatment may be helpful, but almost inevitably patients will eventually need surgical aid. Alcohol injections to the various branches of the trigeminal will give prompt relief, usually for periods of about a year, but in some instances patients have been relieved by this means for as long as three to five years. If the patient has a true trigeminal neuralgia, and if the alcohol has penetrated the nerve fully, there will always be relief. The reason for the saying that 'alcohol injections are often not effective' is that either the patient is not suffering from a true trigeminal neuralgia or else the alcohol injection has not reached the substance of the nerve itself but gotten into the tissues around the nerve.

In addition to trigeminal neuralgia, various other types of facial pain occur in the general area of the trigeminal field. Among these are the *sphenopalatine* (Sluders), *gemiculate* and *various neuralgias having relation to dental infections*, together with pains which may be transmitted over the sympathetic nervous system via the blood vessels. In my experience surgical attempts to relieve these pains are futile, with the exception of those which may be related to sinus or dental infection. Such infections obviously should be treated appropriately in the hope that the neuralgia will then subside. Some of the so-called sympathetic neuralgias are greatly benefited by a long continued course of small amounts of belladonna and phenobarbital.

Another not infrequent head pain is that occurring in the occipital region, extending upward toward the vertex and toward the front of the head. This may be a true paroxysmal type of *occipital neuralgia*,

or the pain may be due to a severe grade of *cervical arthritis*. When intractable, and not helped by simple medical means, an occipital neurectomy as a rule gives prompt relief. A less common pain is that due to *temporal arteritis*. Here there is exquisite tenderness over the superficial temporal artery, together with some reddening. Relief is obtained by excision of that portion of the artery involved.

*Primary cancer of the jaws and tongue* produces severe, persistent pain in the branches of the trigeminal nerve which are involved. The pains may often be relieved by deep alcohol injections of the trigeminal divisions or in some instances by intracranial section of the trigeminal root together with the root of the glossopharyngeal nerve if the latter area is involved.

## 2 THE NECK SHOULDERS AND ARMS

A fairly common condition causing pain which may involve the neck or shoulder region and in addition extend down one or both arms is the so-called *scalenus anticus syndrome*. Roentgenograms of the cervical spine may or may not show unilateral or bilateral cervical ribs. As a rule there is tenderness over the brachial plexus region on the affected side, and the radial pulse can be obliterated by putting the arm on the stretch when the head is bent backward and turned toward the opposite side (Halsted maneuver). Division of the scalenus anticus muscle affords relief by taking pressure off the brachial plexus. Sometimes it may be necessary to resect the cervical rib. This syndrome is sometimes simulated by a *ruptured intervertebral disk in the cervical region*, but roentgenograms may help to clear this diagnosis. An oxygen spinogram of the cervical area may show a filling defect. Atrophy of some of the hand muscles is often present when a disk presses against the cervical nerve root. These disks may be removed at operation or the nerve decompressed if it is not feasible to remove the disk.

Both of the conditions just mentioned may have symptoms and signs similar to those of a *cervical cord tumor*. With the latter, however, pain is likely to be more persistent than intermittent and sensory changes up to the level of the lesion are frequent. Likewise, in tumor the deep reflexes below the lesion are exaggerated, the total protein of the spinal fluid is elevated, and there is often a subarachnoid block demonstrable by the Queckenstedt test. Extramedullary tumors are extremely favorable and can almost always be removed successfully with entire return of spinal cord and nerve function. Metastatic and intramedullary tumors also occur in this as in other regions of the cord. The former are prone to cause pain, the latter much less so. In both

these latter tumors palliative measures are usually all that can be accomplished. One of the infrequent types of malignancy which causes pain in the shoulder and arm is the *Pancoast tumor* of the upper lobe of the lung. These, of course, can be diagnosed roentgenologically, and if the tumor is inaccessible, a high chordotomy on the opposite side often gives considerable relief.

*Causalgia*, the 'phantom limb' discomfort and *Raynaud's disease* are other causes of pain in the arms or hands. Cervical sympathectomy is the procedure of choice in these conditions, and the results in Raynaud's disease are usually brilliant. For causalgia, this procedure is effective in perhaps half of the cases.

### 3 THE TRUNK

In this area of the body, *metastatic malignancy* and *benign cord tumors* are the most frequent conditions for which neurosurgical aid is sought. Radiation treatment for the former should usually be tried, but if pain persists, a chordotomy well above the level of growth should be performed if patients are likely to have a fairly long survival. The usual neurologic and spinal fluid studies will ordinarily suffice to diagnose the level of cord tumors, and when bone has become involved by a malignant growth this will be shown by roentgenograms. "Dumb bell" tumors, involving the chest as well as the spine, are uncommon but are usually benign and can be removed from each area by separate operations. 'Intercostal neuralgia' or *radiculitis* and *post-herpetic pain* around some portion of the trunk are conditions for which procaine followed by alcohol injections into the nerves paravertebrally may be tried, or in the case of herpes, procaine into the skin where it is extremely hyperesthetic. Occasionally posterior rhizotomy of the nerves involved must be resorted to.

The *gastric and renal crises of lues* cause severe pain in the abdomen and kidney regions, respectively. If not affected by antileptic treatment, they can frequently be relieved by chordotomy. *Ruptured intervertebral disks* causing pain in the trunk are extremely rare in the thoracic region, but if such a condition can be diagnosed the disk, of course, should be removed.

### 4 THE PELVIS AND LEGS

In these lower parts of the body, again *primary and metastatic malignant tumors* play a prominent role in the causation of intractable pain. When such conditions are inoperable, chordotomy, usually bilateral, is as a rule the treatment of choice. However, the injection of 0.5 to 1 cc. of absolute alcohol into the subarachnoid space at the proper level for the pain may be tried.



Large numbers of patients suffering from low back pain and pain down the sciatic nerve area have been found to have a *ruptured intervertebral* disk or disks. Some 95 per cent of these protrusions occur between the fourth and fifth lumbar vertebrae or between the fifth lumbar and the sacrum. Rarely they are in the upper lumbar areas and not infrequently they are multiple. The history of chronic, intermittent bouts of low back pain, with pain usually radiating down the back of the leg, is highly suggestive of this condition. Examination shows a variety of signs such as difficulty in bending forward, a list toward the side of the lesion, inability to have the examiner raise the leg on the affected side up to an angle of perhaps 45 degrees without causing severe pain either in the low back or down the leg and a hypesthesia along the back of the thigh, over the toes or just below the external malleolus. The ankle jerk on the affected side may be absent. When there is difficulty with the diagnosis, a lumbar puncture and lumbar spinogram with oxygen will serve to rule out tumor. If the pain is sufficiently persistent and prevents the patient's usual activities the disk should be removed. Most patients do extremely well after such a procedure, but the results are disappointing in a small percentage of cases.

*Lower spinal cord and cauda equina tumors* cause pain in the low back and legs. The pain is persistent rather than intermittent as in the case with ruptured disks, while the reflex and sensory changes are likely to be more pronounced. Lumbar puncture as a rule shows xanthochromic fluid with a high protein content, and often a subarachnoid fluid block. Pain is almost always relieved by removal of the tumor.

*Scar tissue* from an old lumbar fracture which has injured the cauda equina may give severe pain around the hips or down the legs. An attempt may be made to deal with the scar locally, but often recourse must be had to a chordotomy. Intractable "neuritis" of the cauda equina without recognizable etiology may likewise call for a chordotomy if it does not yield to conservative measures.

*Causalgia, Raynaud's disease and endarteritis* are types of pain in the lower extremities which require sympathectomy. As stated before the chances are about even that the causalgic pain will be benefited, and if not, the only other treatment of known value is chordotomy, although one or two instances of excision of the cortical center for pain of this character have met with success.

The *lightning pains of lues* occurring in the legs as a rule are amenable to chordotomy if unrelieved by medical treatment, and the same operative procedure has occasionally been found the only means of relieving severe degrees of pain from *osteoarthritis*.

# CARCINOMA ASSOCIATED WITH ESOPHAGEAL DIVERTICULUM

## Report of a Case

WALTER B. HOOVER

An esophageal diverticulum is a rare occurrence in general practice and many physicians never have seen a case in their own practice. Carcinoma of the esophagus, however, is less rare and most general practitioners have come in contact with such a case.

Of 185 surgical cases of esophageal diverticula at the Lahey Clinic, two cases have been further complicated by carcinoma, an incidence of 1.08 per cent. This incidence of cancer in patients with diverticula of the esophagus is much greater than the incidence of esophageal carcinoma in the general population.

The chronic irritation and inflammation in diverticula of considerable size must be considered a predisposing factor. The incidence of carcinoma associated with other lesions of the esophagus further bears out the impression that the irritation and inflammation are predisposing factors. I have seen carcinoma associated with 15 per cent of the cases of cardiospasm. In cases of diverticula and cardiospasm in which cancer occurred the patients gave a long history, and a large diverticulum or a very large esophagus was present, with much retention and inflammation.

## REPORT OF A CASE

A man, aged fifty-six years, came to the Clinic September 6, 1944, with the chief complaint of throat trouble for the past ten years. He had had pneumonia and an operation for duodenal ulcer in 1926, but no other illness. The present illness began insidiously more than ten years before he came to the Clinic when he noticed that he had to clear his throat frequently, especially at meal time. There was a sensation of food sticking in the throat and the food would either return to the mouth or pass on down the esophagus. Between meals he often raised a mouthful of mucus, an ounce or more at a time. During the past year there had been marked difficulty in swallowing, much regurgitation, and a loss of 20 pounds in weight.

Physical examination revealed a tall, thin man, weighing 157 pounds, who appeared to be at least ten years older than his stated age (fifty-six). The pulse rate was 84, with regular rhythm, and the blood pressure was 95 mm of mercury systolic and 65 mm of mercury diastolic. The heart and lungs were within normal limits, the only positive find-

ings were hypotension, external hemorrhoids and the esophageal diverticulum. A roentgenogram of the esophageal diverticulum showed a filling defect in its anterior portion which proved to be carcinoma on direct examination and by biopsy. The patient was considered to be a satisfactory operative risk.

At operation the usual incision on the left side was made for the first stage resection of an esophageal diverticulum by Dr. Lahey. No evidence of metastases was found in the cervical nodes but the diverticular sac could not be separated from the esophageal wall anteriorly because of the firm growth in this region. The mediastinum was packed off with gauze and the incision closed.

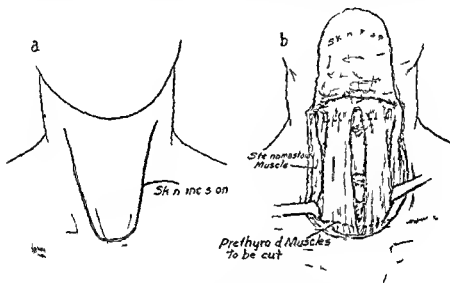


Fig. 39. a. Position of skin incision.

b. The skin flap with the platysma elevated and the exposure of the anterior portion of the neck including the hyoid bone to the manubrium. The incisions are marked off for the removal of the prethyroid muscles.

Suspension laryngoscopy and esophagoscopy were carried out ten days later. This revealed the growth to be in the anterior portion of the diverticulum and in the esophagus with the posterior wall of the diverticulum quite free from the growth.

Dr. Lahey then walled off the upper mediastinum on the right side by an operation similar to the one carried out on the left side. There was no evidence of metastases in the nodes of the right side of the neck.

With the upper mediastinum and fascial planes of the neck walled off on each side it was felt safe to carry out an extensive procedure even though there might be escape of contaminated secretion. Under general anesthesia with an intratracheal catheter in place the original

incision on the left side of the neck was opened and the laryngeal area, the area of the thyroid and the diverticulum were explored to determine whether the esophagus could be detached from the larynx and trachea. The diverticulum was opened on the left side and a catheter was placed in the esophagus. However, it was found that the carcinoma extended directly into the left lobe of the thyroid gland and was firmly attached to the cricoid cartilage posteriorly (Fig 332). Therefore, it was decided to remove the anterior three-fourths of the

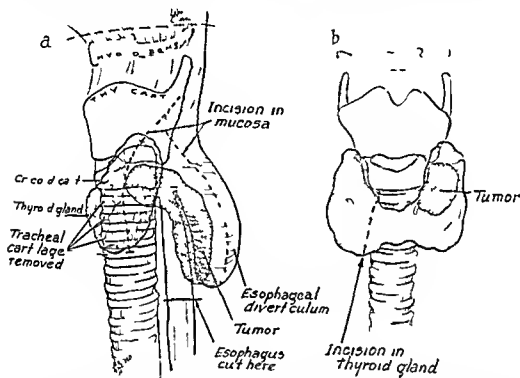


Fig 330—*a* and *b*, The extent of the malignant tumor is shown with its relation to the diverticulum, esophagus, cricoid cartilage and thyroid gland. Lines are labeled to show the relative positions of the incisions which were made through the mucosa, trachea and esophagus for the resection of the malignant growth. The hyoid bone and thyroid cartilage were removed, which permitted considerable elongation of the anterior flap of mucous membrane.

diverticulum, the hyoid bone, the thyroid cartilage, and the anterior portion of the cricoid cartilage, saving the mucous membrane of the anterior portion of the larynx to form the anterior wall of the upper esophagus (Fig 331), and saving a strip of the posterior wall of the diverticulum for the formation of the posterior wall of the upper esophagus.

To carry out this procedure the incision on the right side of the neck was opened and the two incisions connected by a transverse incision at their lower ends (Fig 329 *a* and *b*). The flap was reflected upward, exposing the prethyroid musculature and the hyoid bone.

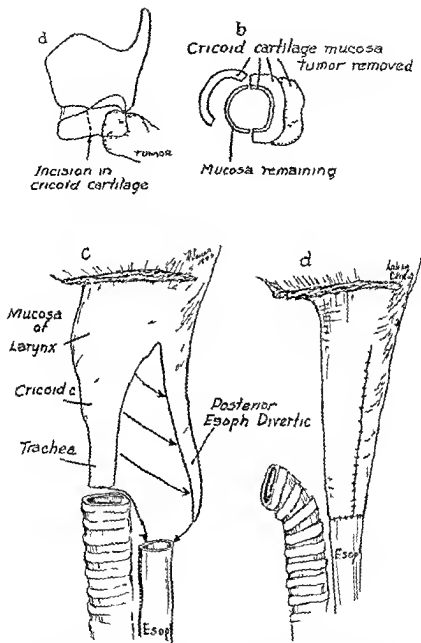


Fig 331.—*a* and *b*, Diagrammatic sketches showing relation of the tumor to the cricoid cartilage and the anterior mucosal flap which was saved to form the anterior wall of the upper esophagus

*c* and *d*, The mucous membrane flaps after removal of the tumor and their attachments to each other and to the cut off esophagus are shown

The prethyroid musculature was removed, the superior thyroid vessels were exposed and tied, and the hyoid bone was removed. The greater portion of the thyroid cartilage was removed, leaving the mucosa of the pyriform sinus and the epiglottis.

The upper end of the trachea was exposed by excising the thyroid isthmus and a small portion of the right lobe of the thyroid gland. The left lobe of the thyroid remained attached to the posterior portion of the larynx and esophagus and was later removed with them. The posterior aspect of the trachea was readily dissected from the anterior wall of the esophagus. The intratracheal tube was withdrawn. The trachea was divided and its anterior wall sutured to the skin in the midline. A second sterile intratracheal tube was inserted and passed to

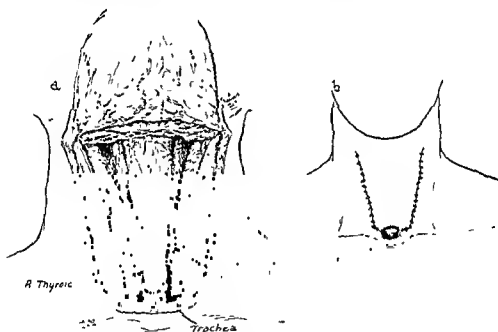


Fig. 332.—*a*, The completion of the operation before closure. *b*, The method of closure.

the anesthetist under the drapes, and the anesthesia was continued. The mucosa in the anterior portion of the cricoid cartilage was dissected free and a strip of mucosa on the anterior half of the larynx was then turned upward, exposing the posterior half of the larynx, the lower portion of the pharynx and the diverticulum. The upper end of the esophagus was opened behind the trachea, exposing the catheter previously placed, and permitting a view of the posterior esophageal wall with its growth. With good visualization, the growth was removed with considerable margin of apparently unaffected tissue. In all,  $2\frac{1}{4}$  inches of the upper esophagus was removed.

The flap of mucosa on the posterior wall of the diverticulum was mobilized sufficiently to be sutured to the mucosa of the esophagus

posteriorly and the flap of mucosa from the larynx was stretched so that it could be sutured to the esophagus anteriorly, forming a new esophagus (Fig 331, *c* and *d*). The catheter was withdrawn and a Levine tube placed for feeding. The edges of the two mucosal flaps were sutured to the sternomastoid muscle to hold them in place and to prevent tension on the lower esophageal sutures. Sulfanilamide was dusted into the wound. The anterior mucosal flap was sutured to the cutaneous flap, the incisions of which in turn were closed by subcutaneous catgut sutures and black silk sutures to the skin (Fig 332). The lower end of the flap was attached to the posterior wall of the trachea. A cigaret drain was placed in the upper part of the wound and also on each side, near the lower end of the lateral incision. A tracheotomy tube, made to fit snugly by wrapping it with sulfathiazole gauze, was placed in the trachea and a pressure dressing applied. Sulfadiazine, 2.5 gm in 1500 cc of saline and glucose solution, was given intravenously. Sulfadiazine and feeding were continued through the Levine tube.

Healing was rapid, with the exception of the tracheal stump, one ring of the trachea sloughed away either because of poor blood supply or from pressure.

On October 18 the patient was able to swallow without leakage. The Levine tube was removed. A flap of skin from below the trachea was sutured about the tracheal stump, covering the denuded area.

The patient was discharged from the hospital on October 26, twenty-seven days after the removal of the carcinoma with its surrounding involved tissues. Following discharge the patient was able to swallow well for three months. During this time enough contracture occurred to produce some dysphagia. Dilatations were necessary and have been carried out over a swallowed thread with Plummer dilators.

## PRIMARY CARCINOMA OF THE JEJUNUM

BERNARD J. FICARRA AND SAMUEL F. MARSHALL

THE literature on malignant tumors of the small intestine clearly indicates that this entity is listed among the rarities in surgery. Small bowel carcinoma has a reported incidence ranging from 0.47 per cent to 6 per cent of all gastrointestinal cancers.<sup>1 2 4 5 7 8</sup> These studies are based on surgical specimens and autopsy material. Hence, it is an infrequent experience for one surgeon to encounter many of these cases during his professional life.

In order of frequency, the duodenum is the most common site of carcinoma, if carcinoma of the papilla is included. The ileum is the next site most often involved, with the jejunum acknowledged to be the least common location for cancer. A study of primary cancer of the jejunum at the Lahey Clinic coincides with the experience of others in that jejunal cancer should be listed among the rarer neoplasms. From 1915 to 1933, thirteen cases of small bowel carcinoma were reviewed by Kiefer and Lahey.<sup>4</sup> Of this number only six were true primary cancers of the jejunum. In the five years surveyed between 1933 and 1938, Chamberlin<sup>8</sup> reported nine additional cases encountered at the Lahey Clinic, four of these were primary in the jejunum. Our review from 1938 to January 1945 brought to light seven new cases of small intestinal cancers. Of this number only two were primary jejunal neoplasms. Thus over a period of thirty years twelve cases of primary carcinoma of the jejunum have been encountered at the Lahey Clinic.

### PATHOLOGY

Grossly, tumors of the small intestine are either annular constricting or asymmetric tumors. The former are usually carcinoma. The asymmetric type may be subdivided into internal and external types according to the direction of growth. Benign tumors frequently grow inward toward the lumen of the intestine. The external type is usually malignant, growing outward into the peritoneal cavity or into the mesentery.<sup>6</sup> Microscopically the lesion is an adenocarcinoma. Adenocarcinoma of the jejunum metastasizes early and, according to some authors spreads first to the mesenteric lymph nodes and peritoneum, then to the liver, lungs, long bones, and dura mater of the spinal cord in the order given<sup>7</sup> (Fig. 333).





Fig. 333—Section of specimen resected demonstrating primary adenocarcinoma of the jejunum (Case II)

#### CLINICAL FINDINGS

The symptomatology is variable. The factors influencing the clinical picture are the absence or presence of obstruction and the location of the lesion in the jejunum. Prior to the obstructive stage the history may be of short (weeks) or long (several years) duration. The symptoms presented are weakness, loss of weight and fatigue. Anemia of various degrees is usually present. The anemia results partly from interference with motility and absorption, and secondly, from the loss of occult blood. Occult blood in the feces is almost always present although tarry stools are not commonly seen.

Complete occlusion of the jejunal lumen due to neoplasm rarely occurs. However, temporary or permanent obstruction may result when food particles are incarcerated in the area of new growth. The small intestine does not tolerate acute obstruction or distention very well, nevertheless it readily adapts itself to a slow progressive obstruction. Adaptation is possible because of extensive hypertrophy of the intestinal musculature. This hypertrophy occurs above the site of obstruction, the resulting increased contraction force often is sufficient to overcome the obstruction.

When obstruction occurs the classical picture of pain, vomiting, abdominal distention, constipation or obstipation is present. A variation in the symptomatology depends upon the location of the lesion in

the upper or lower jejunum. Obstruction in the upper jejunum is slowly progressive with severe epigastric pain developing with the greatest intensity two or three hours after meals. Vomiting occurs early, increasing in frequency and volume as the obstruction progresses. Complete upper jejunal obstruction results in vomiting of large amounts of gastric, biliary and pancreatic secretions. Loss of these fluids produces a rapid dehydration, alkalosis and prostration.

Lower jejunal cancer usually reveals itself by obstructive signs which are slowly progressive, recurrent or acute in type. When the occlusion of the lumen is gradual the symptomatology may be of several months' duration. These complaints may be pain, nausea or vomiting, malaise, anorexia, weight and strength loss. Dehydration and prostration occur later than in upper jejunal neoplasm. The complaints may disappear only to recur at more frequent intervals. Kiefer and Lahey<sup>6</sup> believe that intussusception is produced in about 30 per cent of tumors in the lower jejunum and ileum. Cases may be encountered in which the tumor does not encroach upon the lumen and thereby does not produce a mechanical obstruction. In such instances the lesion is not detected until constitutional exhaustion, secondary anemia, or a palpable mass suggests the true nature of the disease.

#### DIAGNOSIS AND ROENTGENOLOGIC STUDIES

Generally the diagnosis of jejunal carcinoma is made at operation or necropsy. A malignant lesion of the jejunum may be suspected clinically from the history, physical examination and laboratory findings. An exact diagnosis preoperatively demands adequate roentgenologic studies which visualize and localize the lesion.

The most accurate method of detecting a jejunal lesion is by serial roentgenograms taken every hour for five hours following a barium meal.<sup>6</sup> Dilatation of the small intestine with delay in the passage of barium is the most suggestive roentgenologic finding. Filling defects and craters are seldom revealed in the small bowel. Usually when the neoplasm is easily demonstrable by roentgenogram, the lesion is inoperable. Of a certainty, a negative roentgenologic study of the small intestine does not rule out jejunal neoplasm. Only about 25 per cent of primary carcinomas of the jejunum and ileum can be seen by roentgenogram<sup>1</sup> (Fig. 334).

#### PROGNOSIS AND TREATMENT

The prognosis with or without treatment, is discouraging. Carcinoma of the jejunum metastasizes early, and since the diagnosis is often made late, the outcome can only be unfavorable. Kiefer and

Lahey's<sup>6</sup> analysis indicates that the duration of life after resection is one year. Mayo and Netter<sup>7</sup> give seventeen to eighteen months as the average life expectancy after operation.

The treatment is surgical with the most difficult aspect of the problem being the recognition of the lesion sufficiently early for a favorable prognosis. Patients in a debilitated state should have only an enterostomy at the first operation. Later resection of the tumor may be per-



Fig. 334—Obstruction of the jejunum can be seen. (Case II).

formed with an end to end or side to side anastomosis after the patient's condition has improved. When extension of the lesion with metastases has occurred a side-tracking lateral anastomosis around the obstruction may give symptomatic relief. Dr. Lahey has suggested the addition of a jejunostomy above the point of anastomosis in those cases in which primary resection and anastomosis is deemed advisable.<sup>8</sup>

Röntgen therapy is ineffectual treatment. In certain cases this pro-

cedure may even be dangerous because of the possibility of perforation of the intestine due to necrosis of the neoplasm.

### CASE REPORTS

**CASE I**—The patient was a sixty year old male teacher who was admitted to the hospital on January 23, 1940, with a two weeks' history of abdominal pain, nausea, and occasional vomiting. Examination suggested an incomplete intestinal obstruction. The significant past history was an appendectomy and Mikulicz resection performed elsewhere in March 1933 for carcinoma of the sigmoid. He entered the Lahey Clinic for closure of the colostomy and was discharged on July 20, 1933, following this procedure. At the time of his admission in 1940, laboratory studies were not significant.

On January 26, 1940 he was subjected to an exploratory laparotomy. A hard neoplastic lesion was found  $1\frac{1}{2}$  feet from the ligament of Treitz. The lesion almost completely obstructed the lumen of the jejunum at this site. Proximal to the lesion the jejunum was dilated and hypertrophied. One mesenteric node was enlarged. The node and the neoplasm were resected and a lateral antiperistaltic anastomosis performed. Microscopic study of the specimen removed at operation revealed it to be a primary adenocarcinoma of the jejunum with metastasis to the lymph node. The patient had an uneventful postoperative course and was discharged on February 14, 1940. He was last heard from by letter on January 14, 1941. At that time he was symptom free.

**CASE II**—The patient was a seventy seven year old man who came to the Clinic on September 9, 1944, and was admitted immediately to the hospital. He gave a history of avoidance of rich and heavy foods for the past six months. This avoidance of certain foods was intentional in order to lose weight. Three months before his hospital admission he had lost 24 pounds and attempted to regain it, without success. At about this time an acid stomach developed. Shortly thereafter gas pains occurred in the lower part of the abdomen about one hour after eating. 'Heartburn' developed at night and was relieved with alkali. Several episodes of vomiting—somewhat obstructive in type—had occurred since July 1944. On occasion the vomitus contained particles of food eaten two or three meals previously. Constipation without melena had been noted since February 1944.

Physical examination demonstrated that the patient was very slender, poorly nourished and appeared chronically ill. Examination of the abdomen revealed visible intestinal patterns through a very thin abdominal wall. No masses could be felt. The remainder of the examination did not reveal any abnormality. A malignant lesion of the gastrointestinal tract was suspected. Erythrocytes numbered 3,720,000, leukocytes 7,950, and the hemoglobin was 10.5 gm.

After adequate preoperative preparation, the patient was subjected to an exploratory laparotomy on September 20, 1944. At that time an incomplete jejunal obstruction was found 3 feet from the ligament of Treitz due to carcinoma. The lesion was resected and a lateral anastomosis performed. The patient's postoperative course was complicated by urinary retention necessitating a suprapubic cystotomy. In spite of this cystotomy, the nonprotein nitrogen of the blood continued to rise to 65 mg. He finally succumbed to his illness on October 13, 1944.

#### SUMMARY

It has been accepted knowledge that primary carcinoma of the jejunum is a rare entity. Our experience and the past experiences of others at the Lahey Clinic corroborates this belief. Over a thirty year period twelve cases of jejunal cancer, including the two cases herein presented, have been studied.

The diagnosis of this disease is often difficult, since it usually has an insidious onset. Prognosis is very unfavorable with or without treatment. The only effective treatment is surgical removal, which may be performed in one or two stages.

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## THE SURGICAL TREATMENT OF ISLET TUMOR OF THE PANCREAS WITH HYPERINSULINISM

FRANK N. AITAN AND SAMUEL F. MARSHALL

THE first operation for islet tumor of the pancreas, undertaken nearly twenty years ago, was unsuccessful. In this case W. J. Mayo<sup>6</sup> found widespread metastasis of the tumor so that nothing could be done to prevent the continued tendency to hypoglycemia and ultimate death of the patient. Soon afterward Rosecoe R. Graham<sup>5</sup> operated on a patient in whom he was able to excise the tumor completely and the patient was cured. Since that time operation has been performed in a growing number of cases with results which have been almost uniformly successful.

In the majority of cases the tumor has been found to be benign but in a large percentage (about 20 per cent) definite or probable malignancy has been observed.<sup>4</sup> In such cases success has been dependent not only on the technical skill of the surgeon but also on good judgment in diagnosis and on good fortune in operating before metastasis has occurred.

Operation must be performed early. At the same time there must be sound indications for surgery. Islet tumor of the pancreas is manifested by hyperinsulinism causing fall in the blood sugar, but it is by no means the sole cause of hypoglycemia. There are a good many cases on record and probably many more unreported in which exploration of the pancreas has failed to disclose a tumor. In such cases surgical treatment, even radical resection of the pancreas, has rarely led to lasting benefit.

The total number of proven cases of islet tumor of the pancreas is still well under 200. Few institutions have had more than one or two cases. There is, therefore, advantage in accumulation of additional knowledge concerned with the diagnosis and treatment of the condition, with a report on the circumstances in each case.

At the Lahey Clinic, operation has been performed for hyperinsulinism in four cases and in each case an islet tumor has been found and removed. One of these has been reported previously.<sup>3</sup> A summary of all four is presented here.

### CASE REPORTS

CASE I.—A woman of thirty-five had an attack in which she became disoriented for several hours with gradual recovery. It came on at a

time when she was hungry. Similar attacks occurred at frequent intervals for three years. They were all manifested by a feeling of hunger and dimness of vision at the onset, then she became disoriented and had aphasia for from thirty minutes to several hours. She discovered that taking food would prevent or minimize the symptoms, but in spite of precautions, the attacks were occurring more frequently. As a rule they occurred at 11 o'clock in the morning and were worse if she had failed to eat her usual breakfast.

Fasting blood sugar values were reported 66, 49, 40 and 35 mg per cent. On surgical exploration, an adenoma, about 1.5 cm in diameter, was found in the body of the pancreas. The left half of the pancreas including the growth was removed. The tendency to hypoglycemia was abolished completely after the operation. For the first seven days the blood sugar was above normal, the highest report was 250. Later tests were normal.

CASE II—A man forty-six years of age came to the Lahey Clinic on May 2, 1940, because he complained of fatigue, which had handicapped him during the preceding two years. Along with fatigue he described a feeling of tightness at the back of his neck, followed by a sensation of numbness in his lips and unsteadiness on his feet. His symptoms had appeared soon after the hurricane in 1938, which resulted in loss of his job as well as loss of personal property. It was difficult to secure exact information in regard to the nature of his symptoms. He was obviously nervous and it was concluded that the symptoms were due to his nervous state.

He returned on January 20, 1943, and described an experience which occurred the month before. One morning when he was due to report for work he heard the alarm clock go off and indicated to his wife that he heard it. Later when she called him to breakfast he responded, but when he failed to appear she came up to the bedroom and found that he was in a stupor. He tried to get out of bed but he swayed and nearly fell. Three hours later he gradually regained consciousness. He asked his wife why he was not at work. He had no memory of what had occurred during the morning. At this visit he described weak spells which had occurred about 11 o'clock in the morning when at work. He found that the nervous, shaky feeling with faintness could be relieved by eating something sweet, such as a chocolate bar.

The possibility of hypoglycemia was now recognized. The suspicion was confirmed when blood sugar tests were reported 50, 44 and 45 mg per cent. Exploration of the pancreas disclosed a tumor, 1.5 cm in diameter, located in the body of the pancreas about 6 cm from the left end. The distal two-thirds of the pancreas was removed, including the tumor.

At 4 P.M. on the day of operation the blood sugar was 236. Fasting

blood sugar reports on the next three days were 263, 244 and 321. There was thus evidence of definite diabetes mellitus and treatment with insulin was employed to control it. Improvement occurred rapidly and it was possible to omit the treatment with insulin before dismissal from the hospital. Subsequently the blood sugar tests were normal and he was entirely free from symptoms.

CASE III—A woman of thirty-six years complained of attacks of unsteadiness, occurring at intervals for a year and a half. On two occasions she had fallen. In addition, she complained of feeling unusually tired. At the time of her visit to the Clinic the weak spells were occurring about twice a week at times when the stomach was empty, usually between 11 and 12 in the morning and between 3 and 4 in the afternoon. She had thought that eating something might abort the attacks or prevent them. The predominant symptoms as a rule were faintness, unsteadiness in walking, profuse sweating and sometimes a confused mental state. At a later time she passed into a stupor. As it came on she felt faint, nervous and had peculiar sensations in her extremities with involuntary twitching. She was given sugar in orange juice on advice given by telephone. Recovery occurred gradually.

Blood sugar values were reported 63, 45, 56, 42, 47, 40 and 45 mg per cent. At operation a tumor was found in the anterosuperior portion of the head of the pancreas beneath the duodenum. The tumor was excised with alternate clamp and scissors technic. It measured 1.5 cm in diameter. Fasting blood sugar values made on the days following operation were reported 191, 163, 133, 180 and 95 mg per cent. Later tests were normal. The patient remained entirely free from symptoms.

CASE IV—A twenty-five year old man came for examination because of attacks of weakness which had been occurring for two and a half years. At the beginning he had an attack of unconsciousness which occurred during the night so that he could not be aroused in the morning. He was admitted to the hospital elsewhere and was given glucose solution intravenously. Recovery occurred immediately. Several similar attacks of unconsciousness occurred subsequently. In addition, he complained of mild attacks of weakness occurring between meals, accompanied by sweating, faintness and irritability. He had learned that eating would give him relief.

Blood sugar values made at the Clinic were reported 55, 44, 45 and 45 mg per cent. Exploration of the pancreas disclosed a tumor 2.5 cm in diameter located in the head just to the left of the gastroduodenal artery. The tumor was dissected out. After the operation the blood sugar rose to 143, but other tests were entirely normal. He was completely free from hypoglycemic symptoms subsequently.



time when she was hungry. Similar attacks occurred at frequent intervals for three years. They were all manifested by a feeling of hunger and dimness of vision at the onset, then she became disoriented and had aphasia for from thirty minutes to several hours. She discovered that taking food would prevent or minimize the symptoms, but in spite of precautions, the attacks were occurring more frequently. As a rule they occurred at 11 o'clock in the morning and were worse if she had failed to eat her usual breakfast.

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At 4 P.M. on the day of operation the blood sugar was 236. Fasting

335 Furthermore in a case studied by Conn decided changes in the blood sugar curve were demonstrated in the same individual depending on the diet given the patient prior to the test

Next in importance to the demonstration of low blood sugar and its relation to the patient's symptoms to the blood sugar level is the elimination of nonpancreatic causes of hypoglycemia. In most cases in which there is no obvious disease of the liver or adrenals, the pancreas is likely to be at fault

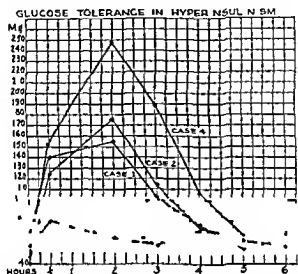


Fig 335—Note the variability of the blood sugar curves. There is no characteristic pattern in hyperinsulinism. The low fasting blood sugar is most important.

The judgment in regard to exploration of the pancreas is of the greatest importance. The indications for exploration of the pancreas which we have followed may be listed as follows: (1) repeated fall of the blood sugar below 50, (2) simultaneous occurrence of severe symptoms causing disability in spite of attempts to relieve them by dietary regulation, (3) definite relation of the symptoms to the blood sugar level shown by relief after ingestion of sugar, and (4) exclusion of disorders affecting organs other than the pancreas.

#### SURGICAL TECHNIC

The pancreas was approached through the gastrocolic omentum. In each case careful palpation of the entire pancreas was necessary to disclose the tumor, since the largest was only 2.5 cm. in diameter. It is only when the tumor is fairly large or near the surface that it can be recognized by inspection. In two cases the tumor was found in the head of the pancreas and was dissected out. In the other two cases the tumor was located in the left half of the tail of the pancreas. Here

the distal portion of the pancreas including the tumor was resected. The risk of malignancy makes wide excision advisable. Careful ligation of all bleeding points is important. In an effort to prevent pancreatic fistula the capsule was sutured carefully with silk stitches. The risk of leakage is still present, and drainage should be provided. Cigarette drains were inserted and led from the site of the operation to the exterior through a stab wound in the abdominal wall.

#### PATHOLOGIC REPORT

In all four cases Dr. Shields Warren described the tumors as typical islet cell tumors of the pancreas. In three cases the report was 'low grade adenocarcinoma of the islets of the pancreas', in the other case the preservation of the tissue was unsatisfactory and the exact classification could not be made.

#### POSTOPERATIVE RESULTS

In each case the removal of the tumor was followed by complete relief from the tendency to hypoglycemia and the symptoms which had led to disability. In two cases there was temporary hyperglycemia. These were the cases in which a large part of the pancreas was removed. The diabetes which resulted was severe enough to require treatment with insulin in one case, but the disturbance of carbohydrate metabolism was only temporary. Before dismissal from the hospital the blood sugar was stabilized in all cases and subsequently there was no need for dietary treatment.

From the surgical standpoint the postoperative course was free from any complications of importance. In one case there was discharge of a considerable amount of fluid thought to be pancreatic secretion but the flow decreased after the first week and the fistula closed within two months. In the other cases the drainage was relatively slight.

#### SUMMARY

Experience with hyperinsulinism due to islet tumor of the pancreas has been reviewed. Operation has been performed at the Lahey Clinic in four cases. In each case an islet tumor of the pancreas was found and successfully removed, with relief from disabling symptoms. The high incidence of malignancy in our experience with this type of tumor shows the importance of early diagnosis.

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MAYO CLINIC NUMBER

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# THE SURGICAL CLINICS of NORTH AMERICA

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## SYMPOSIUM ON ANESTHESIA

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### CURARE AS AN AID TO RELAXATION IN ANESTHESIA

R CHARLES ADAMS

FROM the inception of anesthesiology physicians have had certain aims in the practice of this specialty. These aims may be condensed as follows: to administer an anesthetic agent which will interfere as little as possible with the patient's normal functions during and after operation, to provide the best possible working conditions for the surgeon, and in more recent years, to promote the patient's welfare in connection with the operative procedure. The achievement of some of these aspirations has been difficult and more often impossible because the prerequisites are the ideal anesthetic agent and the perfect patient. The anesthesiologist of earlier years was particularly hampered in achieving his goal because of inadequate materials and inefficient equipment.

Of the previously mentioned aims, perhaps the one most difficult to achieve consistently is that of providing the surgeon with favorable working conditions. Profound relaxation of the patient is probably the surgeon's most constant and paramount demand of the anesthesiologist. The ideal state of perfect relaxation may be difficult to achieve in certain patients since the anesthesiologist has to compete with so many variables. No known anesthetic agents will safely produce 100 per cent relaxation in all patients. In addition, patients differ widely in their reactions to different anesthetic drugs or to the same drug at different times and under different circumstances. Considerable success has been attained in the production of adequate relaxation by using various anesthetic agents in combination or by supplementing one with another. This tends to distribute the anesthetic load and prevents undue toxic effects resulting from the excessive use of any one agent. Such combinations have been described by Lundy under the term 'balanced anesthesia' <sup>74</sup>

Curare (intocostin)\* is one of the most recent additions to the system of supplementing the effects of one agent by combining it with another in order to provide muscular relaxation without profound depression from the anesthetic agent or without using large doses. This South American Indian arrow poison has been known for centuries and its effects on the nervous system have been recognized and utilized in experimental laboratory work for many years. The crude preparation was known to possess many toxic side effects due to impurities and it is only in recent years that a pure preparation suitable for clinical use has been available. It is marketed in solution in 5 c.c. vials each cubic centimeter of which contains 20 mg. or units of active curare or a total of 100 mg. in each vial.

During the early years of the clinical use of curare many physicians thought that it might be both injudicious and unsafe to inject even small doses of such a poison into human beings even though the preparation was composed of the drug in its pure form. However, both experimental and clinical work has corroborated its safety, when used cautiously and with due regard to the nature of its effects. Besides it would appear logical that use of an agent whose effect resulted largely from peripheral action might not produce as many untoward results as large doses of an agent whose predominant effect was depression of the central nervous system. Actually the truth of this statement seems to be increasingly apparent as time goes on.

#### PHARMACOLOGY

The pharmacologic actions of curare are not unknown to the medical profession but the main features will be summarized here. Curare is not an anesthetic agent although mild anesthetic properties have been ascribed to it. Its main effect is on the myoneural junction or synapse. It produces muscular relaxation by blocking the nerve to muscle impulses at this point presumably by interfering with normal action of acetylcholine. It affects the nerves to skeletal muscles and also sympathetic nerve impulses but it appears to have little or no effect on smooth muscles or on the heart or circulation. The muscles are affected in the following order: (1) those innervated by cranial nerves, (2) muscles of the trunk and extremities and (3) muscles of respiration, the diaphragm being affected last. While central respiratory depression has been reported, the peripheral effects are predominant. Large doses paralyze respiratory function by peripheral action. Curare is destroyed in part by the liver and eliminated by the kidneys although some of the drug is excreted unchanged. Judicious therapeutic doses rarely produce side effects. Curare is effective when administered intramuscularly or intravenously but when it is used in connection with an anesthetic agent intravenous administration is preferred. When the drug is given intravenously, its effects appear within sixty seconds and are maintained by E. R. Squibb & Sons, New York City.

the maximum effect may be evaluated in two or three minutes. Intravenous administration favors better control of, and balance between, the effects of the curare and those of the anesthetic agent. Therapeutic doses produce minor degrees of respiratory depression in a small percentage of patients but this is seldom of serious consequence and is easily controlled. Single large doses may result in respiratory paralysis but unless a gross overdose has been administered the use of artificial respiration with oxygen will re establish normal respiratory function. Physostigmine and neostigmine may be considered as specific antidotes although of the two, physostigmine is thought to have a more specific antidotal effect. This drug should be available when curare is being used but if curare is administered in safe amounts there should seldom, if ever, be occasion to use it.

#### CLINICAL USE

The first clinical use of curare was in psychiatric practice for the purpose of ameliorating the traumatic effects of the various types of shock therapy. It is still being used extensively for this purpose, comparatively large doses being employed. Although these doses may be safe enough when employed without anesthesia, they can produce acute respiratory paralysis when superimposed on the pre existing effects of an anesthetic agent.

Cyclopropane has been considered the anesthetic agent of choice for supplementing with curare, due to its evanescence and the rapidity with which the depth of anesthesia may be varied. Because of the flexibility of cyclopropane anesthesia, it has been thought that it is easier to differentiate the effects of cyclopropane and curare than the effects of other combinations and to compensate for them. In addition, cyclopropane apparently does not have the curare like action of agents such as ether, avertin (tribromoethanol) and pentothal sodium.

Although cyclopropane is no doubt still the agent of choice for combination with curare, it is now generally believed that the use of other agents need not be hazardous, provided small doses are employed. In recent years curare has been used with nitrous oxide, ethylene, ether and pentothal sodium. When curare is used either with ether or pentothal sodium, the total amount as well as the individual doses should be smaller than with cyclopropane and the interval between doses should be longer in order to evaluate their full effect.

There has been some difference of opinion as to the size of the initial subsequent and total doses of curare. When it is used with cyclopropane some workers administer 5 c c (100 mg). This amount is no doubt safe in the hands of those who are experienced in using the drug, however, at the Clinic we prefer to use 2 to 3 c c (40 to 60 mg). If adequate relaxation is not obtained in five minutes, we administer an additional dose of 1 to 2 c c (20 to 40 mg). If the initial dose has produced a satisfactory effect no further curare is added until

just before the peritoneum is to be closed. If the anesthetic agent is ether or pentothal sodium I feel that the more conservative dosage is indicated.

During the last twelve months my associates and I have used curare with both ether and pentothal sodium for a variety of operations. Many of these operations were performed on the upper part of the abdomen although some were abdomino pelvic procedures. No untoward effects, either immediate or remote, have resulted. The amount of ether or pentothal sodium necessary is reduced 50 per cent or more, with excellent relaxation in most cases. Amounts of curare in excess of 5 c c (100 mg.) have not been employed for any one operation.

I have been particularly interested in the intravenous use of curare with pentothal sodium, since pentothal sodium alone does not always provide the most desirable relaxation for certain types of surgical procedure.<sup>1</sup> It has seemed that the use of this combination, if safe, would provide the relaxation that pentothal sodium alone sometimes fails to produce and at the same time the desirable features of anesthesia produced by pentothal sodium could be attained. In general this premise has proved to be correct although our series of cases at the clinic to date is not large enough to warrant definite conclusions. As a result of the addition of curare, smaller doses of pentothal sodium are required, relaxation is improved and the undesirable effects of large doses of pentothal sodium, such as prolonged sleeping time, have been markedly lessened.

This combination has not been administered for abdominal operations but it has been used satisfactorily in other fields, for example, in direct laryngoscopy (suspension laryngoscopy). In the past our routine procedure consisted of thorough cocaineization of the pharyngeal and laryngeal regions, using pentothal sodium as the general anesthetic agent. Despite the cocaineization, the activity of the laryngeal reflexes in many patients necessitated the use of comparatively large doses of this drug in order to relax the vocal cords. Many of these patients had a protracted recovery. The use of curare markedly reduces the amount of pentothal sodium required and, as a result, the period of recovery is shortened. After anesthetization of the glottis with 10 per cent cocaine, anesthesia is induced with pentothal sodium until upper first or second plane, third stage anesthesia has been attained. One to 2 c c (20 to 40 mg.) of curare is then administered intravenously. If adequate relaxation is not obtained in three minutes and provided respiratory function is active, an additional 1 to 2 c c (20 to 40 mg.) is given. The balance of the operation usually can be accomplished by use of a few cubic centimeters of pentothal. Nitrous oxide, 50 per cent, and oxygen, 50 per cent, are administered by nasopharyngeal catheter throughout the procedure. This combination of pentothal sodium and curare is providing the best operating conditions we have yet attained for a type of surgical procedure that presents more than the usual

number of problems. A similar sequence is being employed for esophagoscopy in difficult cases.

The use of curare as an aid to relaxation in anesthesia is still in its infancy and its administration should continue to be tempered with caution until our experience and knowledge of its effects with various anesthetic agents is more mature. Its application to anesthetic practice presents many intriguing possibilities and there is every indication that it will have an important part in the future practice of anesthesiology. Those who did the preliminary experimental and clinical work with curare (intocostrin) may well be complimented on the conservative attitude with which they introduced this useful agent to anesthesiology.<sup>2, 3</sup>

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## ANESTHESIA IN SHOCK

JOHN S LUNNY

IN order to make this consideration brief, it will be assumed that all anesthetic agents and methods are available, otherwise, there would be little choice.

The difficulty of defining shock seems to make it necessary to describe the condition which I interpret as shock. I fully realize that it is difficult to define shock particularly from the standpoint of the research physiologist. The shocked patient is more or less prostrated, he is usually conscious although he may not be, his skin is cold and wet and white in contrast with the pink, warm and dry skin of a well person. His blood pressure is usually lowered to a point where muscle tone is markedly decreased, the pulse is usually fast and thready and the pulse pressure is low (less than 20 mm. of mercury). Dyspnea and apprehension may be present. The patient may have suffered an injury and may have lost blood. He may have been exposed to a strong electric current. He may have become weakened through a long debilitating disease and may have been bedridden for a long time. In the latter case, it is sometimes difficult to say whether the patient is simply weak or whether some degree of shock has developed.

The condition which I wish to consider is one that is sufficiently marked so that a clinician would not hesitate to say the patient was in shock. If an operation is necessary, an anesthetic must be employed if the patient is conscious and it may be advisable to use some kind of anesthetic if the patient is not fully conscious. Pain itself seems to contribute to shock or at least to the lowering of blood pressure if the pain is prolonged and severe.

It is essential that general supportive measures be instituted. As soon as the patient shows some improvement from this treatment, it is possible to begin the administration of the anesthetic without preliminary medication. It is much safer, however, to withhold the anesthetic until definite improvement occurs, that is, until the systolic blood pressure can be elevated to an arbitrary level of 100 mm. of mercury, until the pulse pressure reaches 20 mm. or more and until the pulse rate becomes 120 or less. Under these circumstances, the patient has begun to show improvement although he is still weak and there is plain evidence of shock.

The safest anesthesia is accomplished by infiltration with a minimal quantity of a 0.5 per cent solution of procaine hydrochloride. There are operations, however, that are so extensive that local anesthesia is not, by itself, satisfactory. For such operations it is necessary to use some other type of anesthesia with or without the addition of local

infiltration In general, spinal anesthesia should be avoided Intravenous anesthesia with pentothal also should be avoided Although it is possible to use spinal anesthesia or intravenous anesthesia in the presence of shock provided that the anesthetic technic is modified so that very small doses of very weak solutions of the anesthetic agent are used and provided that the patient is well supported with the various measures that are generally available today, there are better and safer anesthetic methods One of the very best methods is to use ethylene and at least 20 per cent oxygen A small amount of ether may be added without untoward effect Nitrous oxide with 20 per cent oxygen may be used A small quantity of ether may be necessary Cyclopropane may be used, but I do not think that it is as good as ethylene in cases of shock Actually, the need for relaxation is not very great, and a powerful anesthetic such as ether or cyclopropane is usually not needed The generous use of oxygen helps considerably and, if spinal anesthesia or intravenous anesthesia with pentothal is to be used, oxygen must be given in a concentration of at least 50 per cent I find that the mixture of 50 per cent nitrous oxide and 50 per cent oxygen is effective in reducing the amount of pentothal required

In some cases of shock, large doses of morphine have been administered because of severe pain In such cases, the required dose of the anesthetic is less than it is in similar cases in which morphine has not been administered In many combat areas, patients have been given morphine after they have been in shock and have become cold Because their peripheral circulation is poor, the absorption of morphine is poor When their circulation improves, the morphine is absorbed quickly and morphine poisoning may occur These patients require supportive treatment more than they need an anesthetic although obviously they need a sufficient amount of anesthetic so that they will not suffer from pain

The use of the intratracheal tube in connection with inhalation anesthesia makes it possible to keep the patient well and adequately ventilated, and it becomes more and more desirable as the degree of shock increases It also is possible to use an inhalation anesthetic in cases in which operation must be performed on the head, face, neck or throat By means of the intratracheal tube and connectors, the anesthetist may be removed from the field of operation and be completely out of the surgeon's way The operative field may be prepared and draped, and the drapes will not be disrupted by the anesthetist during the operation Fluid and secretions that collect in the trachea and bronchi may be aspirated by insertion of a catheter through the intratracheal tube If, during operation, a patient goes into a state of shock, it will be immediately evident to the anesthetist that the patient requires very little anesthetic The blood pressure will fall, the respiratory rate and the pulse rate will increase and the patient will become cold, moist and pale If there has been considerable loss of blood during the operation,



proteins usually expected. Milk, eggs and ground meat are of considerable value with this idea in mind. One gram of protein per kilogram of body weight should be a safe daily subsistence ration. However, for those persons who are sick or have been injured the requirements are frequently greater. Such persons should get approximately 100 gm of protein daily. However in certain cases, for example, cases of old burns it may be necessary to give much greater amounts. If 100 gm of protein daily cannot be administered orally in the forms mentioned previously or in the form of certain commercial amino acid products then there are the protein digest solutions that can be administered intravenously. A good deal of research work has been done on the amino acids and certain commercial firms have been able to produce a product which now is relatively reaction free to the extent that we do not get the generalized reactions or such local reactions as thrombosis, sloughing and so forth. Some firms have products which can be administered subcutaneously usually without local or general untoward reactions.

As far as the carbohydrate diet is concerned, approximately 100 gm is needed daily to prevent ketosis. It is important to administer this amount because if less than this is administered, body protein will be broken down to make up for the deficiency of carbohydrate. Five per cent solution of glucose in distilled water can be administered subcutaneously. However it does produce a good deal of local soreness at the site of injection. Five or ten per cent glucose in physiologic saline solution or distilled water can be administered intravenously. However, occasionally the latter solution has a tendency to produce thrombosis of the veins. Frequently it is desirable to get the glucose into the circulatory system without having to add too much fluid. In such cases the 10 per cent solution is chosen in preference to the 5 per cent solution. If 1,000 c.c. of fluids more or less are immaterial as far as the condition of the patient is concerned then it is preferable to use a 5 per cent solution of glucose.

Fat in a palatable form may be given to most ill patients. Enough water above that formed from food to provide for sensible and insensible loss and to provide for at least 1,000 c.c. of urine daily is preferable. At least 5 gm of salt should be given unless this amount is contraindicated by congestive heart failure, nephritis or nephrosis and edema. A patient who is depleted in salt does not eat or drink well. One thousand cubic centimeters of physiologic saline solution provides 9 gm of salt. Vitamins should be supplied either orally or intravenously as necessary. The following table gives the average amounts of dietary constituents required daily.

Water	7000 to 13,000 cc
Salt	5 to 10 g
Protein	75 to 150 gm
Carbohydrate	100 to 300 gm
Fat	vitamins and calories as required

In administering parenteral fluids it must be remembered that excessively long periods of administering intravenous fluids are very tiring and distressing to the patient. If a patient has to lie quietly in bed while 2,000 to 3,000 c.c. of fluid are running intravenously, he may become very nervous and exhausted and upset to such a degree that some of the beneficial effect of the fluid administered is lost. The patients are warned to remain quiet in order to prevent the needle from becoming dislodged but sometimes they are so restless that the needle does become dislodged accidentally. In such a case the site of injection may become very tender, even to the point of getting a local hematoma and occasionally thrombosis of the blood vessel.

Water saline solution proteins and carbohydrates in the foregoing approximate amounts all may be given intravenously. Protein may be provided in the form of whole citrated blood, blood plasma, hydrolyzed protein and some of the newer preparations of amino acids. Every 100 c.c. of whole citrated blood contains approximately 15 gm. of hemoglobin and 4 gm. of plasma protein. The principal use of this hemoglobin and protein is to increase the blood volume and circulation. Hemoglobin itself is not suitable for tissue protein replacement. However plasma is metabolized to some degree and thus it does provide a source of nitrogen. Five per cent casein hydrolysate in 5 per cent dextrose solution neutralized to a pH of 6.5 is the usual preparation administered. The rate of administration of amino acids must be regulated. If injected too rapidly, they may produce nausea and vomiting. Again, if they are administered too slowly, the patient will experience the aforementioned discomfort. Approximately 500 c.c. of 5 per cent solution of amino acids per hour may be administered and utilized to advantage. Fifteen hundred cubic centimeters of amino acid solution per day is the usual accepted amount. Amino acids administered orally may be given in much greater quantities than this. At the present time there is no fat preparation that may be administered intravenously.

During short illnesses the average patient does not require vitamins. However, in prolonged illnesses the addition of vitamins is important. The average daily requirements of the more important ones are thiamine ( $B_1$ ) 10 mg. riboflavin ( $B_2$ ) 5 mg. nicotinic acid 70 mg. and ascorbic acid (C) 100 mg.

#### SURGICAL PATIENTS

Since the acceptance of the principles of antisepsis and asepsis surgery has made great advances. Often these advances were made without much knowledge of the physiologic part many of the organs being operated on played in the whole picture. Today it is realized that the preoperative preparation and postoperative care of the patient are important factors in the final result of surgical treatment. It is admitted that there is a great variance of opinion relative to the care of patients

It must be admitted that emergencies today are relatively less frequent than they used to be. Bleeding that cannot be controlled except by operation is one of the few acute emergencies. In many cases it is permissible and advisable to do certain further examinations and to carry out certain corrective procedures before the patient undergoes anesthesia and surgical treatment.

The risk of surgical treatment is least when the patient comes to operation with the tissues adequately supplied with fluid, the food reserves in their normal state, the metabolism adjusted as perfectly as it may be, the intestines working normally, the circulation at its optimal level and a nervous system as undisturbed and peaceful as in daily life.<sup>14</sup>

Blalock<sup>9</sup> classified the body fluids as being intracellular and extracellular. One half the body weight is accounted for by the intracellular fluid. Extracellular fluid is made up of blood plasma (6 per cent of body weight) and interstitial fluid (15 per cent of body weight). The intracellular fluid transports nutrient and waste products.

The fluid requirements of a healthy person are usually met by the taking of sufficient water to alleviate thirst and the water in the ordinary diet. Three liters of water made up from drink, food and oxidation of food is an average adult daily requirement.

For those persons who are undergoing surgical treatment, Wagenseen<sup>15</sup> presented four problems which bear on the fluid requirements.

**Water Requirements**—Dehydration is a result of a reduction of the amount of water in the body, the first loss being from the interstitial fluid. Following a certain amount of loss from this source the blood plasma will show a loss of fluid. In many instances this dehydration is directly due to the loss of fluid from the gastro intestinal tract by vomiting or diarrhea. It usually can be determined easily by marked thirst, dryness of the mouth and lips and a higher temperature than one would expect from the particular illness. Signs of acidosis or alkalosis may be present.

Maddock and Collier<sup>11</sup> have suggested a means for calculating the quantity of fluid that should be given to surgical patients who cannot take fluid by mouth.

1. Water for urine 1 500 c.c.

2. Water for vaporization—2 000 c.c.

3. Variable amount of fluid to replace that lost by vomiting, blood, feces, biliary and intestinal fistulas, exudations and so forth.

4. If the patient is already dehydrated, sufficient water to restore depleted body fluids (6 per cent of body weight).

At this point it might be well to point out that general edema is particularly likely to follow the use of large quantities of salt solution when the patients have low serum protein.

**Electrolyte Needs**—If parenteral therapy is indicated, what fluid

should be administered? In many cases in which treatment is surgical, dehydration is not present and in these cases the parenteral administration of fluid may be carried out because temporarily there are certain contraindications to the oral administration of fluid. It is generally agreed that 5 per cent solution of glucose in distilled water is as good as any fluid under these circumstances. The importance of this question increases if the patient is dehydrated. With the exception of the sodium and chloride ions, all the materials used in the plasma structure can be supplied by the metabolic processes of the body, even in the absence of food. Therefore, the administration of physiologic solution of sodium chloride will answer this problem.

If the patient has a renal function within normal limits, the proper retention of sodium and chloride ions and of the materials from the metabolic processes will be performed. The extracellular fluid will be restored. Collier, Bartlett and co-workers<sup>12</sup> have a method of determining the required quantity of sodium chloride necessary to administer. Determine the plasma chloride level; for each 100 mg. per 100 c.c. that the plasma chlorides need to be raised to reach a normal of 560 mg. per 100 c.c., the patient should receive 0.5 gm. of sodium chloride per kilogram of body weight. For the ordinary postoperative patient 5 to 9 gm. of sodium chloride daily is sufficient. Fluids needed above this requirement may be provided by the administration of glucose in distilled water. If there is an impairment of renal function accompanying the dehydration, glucose is indicated. The glucose not only increases the plasma volume and the renal blood flow but it also adds water to aid the functioning of the kidney. Glucose also aids in the oxidation of the ketone acids. Relatively large amounts of glucose solution may be used without too great fear of the appearance of edema. This does not hold true for the salt solutions, particularly if the patient is suffering from low serum proteins resulting from inadequate food intake.

**Blood Loss Factor.**—In many operations the blood loss is almost negligible. However, this does not hold true for many others. The amount of bleeding varies, too, according to the particular technic of the surgeon. One artery bleeding briskly will often lose as much blood for the patient as the whole of the operation otherwise would. Large blood losses should be replaced by a blood transfusion. If the bleeding is not great but yet the patient exhibits need for increasing the blood volume, blood plasma may be given to good advantage.

**Caloric and Nitrogen Requirements.**—It is very easy to err in treatment by not meeting the caloric and nitrogen requirements during the postoperative period. The use of glucose offsets the ketosis of starvation but frequently is not sufficient to meet the energy requirements of the patient. This is doubly important for the preoperative preparation of the patient, especially if he has lost weight. Ravdin<sup>23</sup> has shown that a preoperative combination of high protein and carbohydrate diet

thus deciding each step of treatment for the benefit of the patient. If fluids are needed, be sure a sufficient amount is added.

#### ROUTES OF ADMINISTRATION

1. **Oral Administration of Fluids**—This is perhaps the best route provided there are no specific contraindications. The practice of giving warm sweetened tea or coffee to wounded men as they have been brought to casualty stations was beneficial in the War of 1914-1918, and also in air raid casualties and other cases of wounds in this war. The primary purpose here is to give comfort, warmth, fluid and nourishment but not necessarily to combat shock. However, this route should not be used immediately preoperatively or immediately postoperatively in most instances nor can it be used satisfactorily if the patient is vomiting, has had a serious gastro intestinal operation or has peritonitis or paralytic ileus.

2. **Proctoclysis**—Some of the more desirable features of the rectal administration of fluids are that sterile equipment is not necessary and tap water may be used. On the other hand, undesirable peristaltic waves may be started, the rate and amount of fluid absorbed are unpredictable and some patients complain of being very uncomfortable. This method is very inadequate if it is desired to supply glucose and sodium chloride, as these two solutions are not absorbed readily.

3. **Hypodermoclysis**—Many surgeons prefer this route to others for the administration of fluids. However, in this method the rate and volume of absorption vary a good deal. The two desirable regions of administration are (a) Subpectoral region, the needle being introduced in the anterior axillary line and at right angles to the ribs. If this is done, there is less danger of the needle damaging the pleura and lungs. One objectionable feature is the fact that it frequently results in more or less splinting of the thoracic muscles and interference with free respiratory effort. (b) When the thighs are used, the needle should be inserted just superficial to the fascia on the anterior or lateral surface of the thigh. One of the objections to the use of this method of fluid administration is the discomfort suffered by the patient by distention of tissue spaces and so on. This may be alleviated in part by adding 1 gm. of procaine hydrochloride or metycaine to each 1,000 c.c. of fluid used. Solutions should be used that are most nearly isotonic. This includes isotonic solutions of sodium chloride and 5 per cent glucose. It must be remembered that one can give excessive quantities of fluids by this route also. Care must be exercised in applying heat to an area overly distended by subcutaneous hypodermoclysis. The skin is taut and somewhat avascular and is easily burned.

4. **Intravenous Administration**.—The intravenous route has one great advantage over its fellows in that one can give a known amount of fluid quickly or slowly. By its use one is able to meet certain more or less specific therapeutic fluid needs for the treatment of shock or im-



greater saphenous vein in the groin may be used on occasion (fig 336, *a*) In infants the external jugulars or scalp veins frequently are readily accessible If the patient has an average circulatory volume and veins are not collapsed, one usually can enter one of these veins readily However, if the veins are collapsed or the patient is in shock, heat applied in the form of hot packs to the arms from finger tips to above the elbows or from the toes to above the knees tends to dilate the

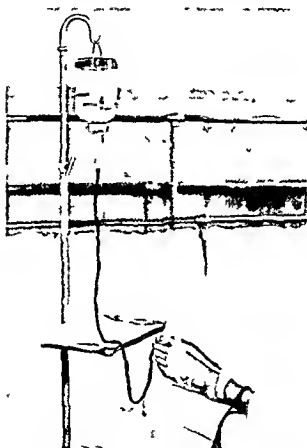


Fig. 337 Intravenous administration of fluids on the operating table The greater saphenous vein at the left ankle is the one being used in this particular case

vessels and they become filled with blood (fig 336 *b*) If a tourniquet is placed on the arm or leg before the hot packs are removed the blood in the part will be dammed into the arm, hand, leg or foot and will keep the vessels dilated In these circumstances it is well to use a warm antiseptic solution to cleanse the skin A cold antiseptic solution tends to constrict the vessels An injection of procaine hydrochloride at the site of skin and vein puncture lends aid by decreasing pain

ful stimuli of the needle, which themselves might produce a sudden constriction of the vessels. Anderson and Lundy<sup>2</sup> made a suggestion that, in cases of severe shock in which it is impossible to get a large needle into certain arm or foot veins, if a tourniquet is placed around the member and a small caliber needle placed into a vein, enough fluid can be injected into the part to dilate the veins and permit the entrance of a larger caliber intravenous needle. Occasionally this procedure may prove very valuable.

In many cases of surgical procedures that are expected to be lengthy or serious or both or in which the patient is in the poor risk class, it is well either to place a 15 gage Lewisohn needle with obturator into a leg or arm vein before the operation starts or even to start one of the

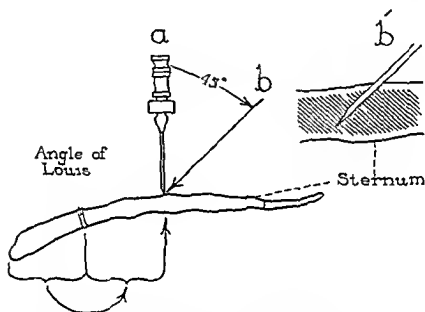


Fig. 338—The approximate distance from the angle of Louis where the needle should enter the bone marrow space

parenteral solutions dripping in slowly. Many surgeons prefer to have this needle placed in one of veins on the dorsum of the foot or the vein anterior to the medial malleolus (fig. 337). This has certain advantages, as the surgeon and his assistants are not inconvenienced by an arm protruding from the side of the operating table. Recently at the Clinic the opinion has been expressed<sup>4</sup> that using ankle or foot veins may increase the incidence of phlebitis and thrombosis in the lower extremities. This opinion is respected and as a consequence several of our surgical services now are using the veins in the hand or arm in preference to those in the lower extremity in order to determine whether or not they do get a greater or lesser incidence of phlebitis and thrombosis in their patients.

5 Bone Marrow Spaces—The procedure of placing especially de-



signed needles into the sternal bone marrow space in adults or the tibial bone marrow space in small children and infants has proved very valuable in certain instances. The point of entrance of the needle in the sternum is one chosen a distance down from the angle of Louis equal to the distance of the angle of Louis from the suprasternal notch (fig 338). For infants three years old or younger, a point is chosen at the junction of the upper and middle thirds of the shaft of the tibia on the anteromedial aspect of the tibia (fig 339). The lower end of the femur may be used also. Gentle aspiration by a syringe usually produces a return of some blood into the syringe. By this method, people in severe shock, whose veins are completely collapsed and not easily entered by venipuncture, persons who are so severely burned that the usual sites of venipuncture are not usable or infants who have no veins into which needles can be easily introduced can be given paren-

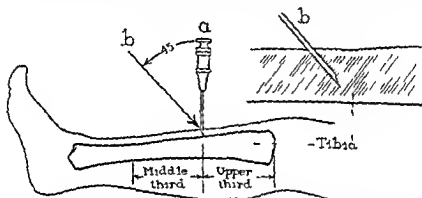


Fig. 339 Diagrammatic representation of a tibia showing the point of entrance of the needle between the middle and upper thirds of the tibial shaft

teral fluids, plasma, blood or other fluids very readily. The rate of administration of fluids compares favorably with the rate at which fluids can be given intravenously.

#### SUBSTANCES

When fluids are to be used, the physical as well as the biologic properties must be considered. Certain fluids are more important for food value than for shock therapy. In shock therapy, Taylor and Waters<sup>30</sup> have set down a specification which if met would be almost ideal:

- 1 The size of the molecules of the solute should prevent ready escape of the solution from the blood vessels
- 2 The osmotic pressure and viscosity of the solution should be as nearly that of blood as possible
- 3 The solution should be isotonic with the erythrocytes
- 4 It should be nonantigenic and innocuous. Its stability, ease of

sterilization and ready availability are also important points to be considered

**Water**—Distilled water alone must not be administered intravenously

**Saline Solution**—Only isotonic solutions of sodium chloride should be used There are relatively few if any indications for the use of a hypertonic saline solution

**Glucose**—Five per cent solution of glucose is the solution most commonly used This may be used either dissolved in distilled water or combined with saline It is preferable to administer it intravenously However, subcutaneous injections of 5 per cent solution of glucose are made A 10 per cent solution of glucose sometimes is used However it tends to thrombose the veins preventing subsequent use of these veins Eight to ten cubic centimeters of 5 to 10 per cent solution of glucose per minute is the optimal rate of intravenous injection If a stronger solution is used the rate of flow should be decreased accordingly Both saline and glucose solutions are crystalloid solutions and consequently remain in the circulation relatively short times Because of this when they are used for immediate treatment for increasing the blood volume, it must be remembered that the effect hoped for will be only transient and if a longer action is desired, then a solution of more value must be used

**Acacia**—Six per cent solution in isotonic saline was used extensively in the last war Many reports bear out its value The use of this solution on occasion has resulted in certain reactions but in recent years the process of manufacture has improved and it would seem that the deleterious effects have disappeared to a great extent Solution of acacia does remain within the circulation for relatively long periods and because of this it is of value as a plasma substitute in shock Lehnhoff and Binger<sup>19</sup> have reported its use in nephrosis It seems to aid the excretion of water with loss of generalized edema It has been shown to be deposited in the liver Consequently many investigators feel that its use may have a deleterious effect on hepatic function

**Pectin**—This is a colloidal carbohydrate complex in composition having a high molecular weight, and is obtained by a special process from citrus juices Hartman and associates<sup>15</sup> have investigated this product and have concluded that it is nontoxic and nonantigenic and is excreted readily within seventy two hours In a 5 per cent solution it has about the same osmotic pressure and viscosity as whole blood It appears to have a more sustained effect as far as increased blood volume and blood pressure are concerned than has saline or glucose solution It does take considerable care and dexterity in its preparation Steam pressure sterilization does not change its physical properties

**Gelatin**—In 1915 Hogan<sup>16</sup> gave a detailed description for the preparation and sterilization of purified gelatin in a 4 per cent solution In 1917 Bayliss<sup>7, 8</sup> found that a 6 per cent solution of gelatin has

approximately the same viscosity and colloidal osmotic pressure as blood plasma. At the Clinic, Cook and his associates<sup>12</sup> have used a 6 per cent solution with seemingly good results in replacing fluid loss in certain cases of elderly patients during and following transurethral prostatectomy. The impression has been gained that there is a quicker response of the return of the blood pressure and this tends to remain within normal limits more readily than when solution of gelatin is not used. This surgical service does not hesitate to use whole citrated blood in cases in which there is considerable loss of blood, however in those cases in which blood or plasma is not specifically indicated, they feel gelatin is giving them a method of quickly improving the circulation by increasing blood volume and blood pressure. There are two solutions of gelatin consisting of a smaller and a larger molecule respectively. The experience gained to date is not sufficient to make a preferential choice between them.

**Isinglass**—This is a form of gelatin and is obtained from the swim bladder of several kinds of fish. Taylor and Waters<sup>29</sup> found that a 7 per cent solution had a colloidal osmotic pressure relatively similar to that of human plasma. Experimentally it seemed to save the lives of animals after hemorrhages that ordinarily proved fatal. Taylor<sup>29</sup> showed that 500 c.c. of a 4 per cent solution would produce a sustained rise in arterial pressure and blood volume.

**Amino Acids**—The most important function of amino acids is the formation of tissue protein. Formerly, it was believed that body proteins were formed during the growing stage of the animal and thereafter the only function of food amino acids was in maintaining and repairing tissue. As Schoenheimer<sup>25</sup> has shown, there is a complete mixing of absorbed amino acids with those already present and there is no differentiation made between "food" amino acids and those of body proteins.

Of the amino acids present in the body, eight must be furnished to maintain nitrogen balance. A daily supply of those eight should be available to man because he can neither synthesize them nor store them. All the essential amino acids must be furnished simultaneously to obtain nitrogen retention. When the nitrogen intake is low, the administration of a mixture of amino acids containing all the essential ones should improve protein synthesis. For many years glucose intravenously administered has supplied the caloric requirements. However, the catabolism of body proteins continues with no possibility of replacement. Whole blood or blood plasma may supply this in part, however, the nitrogen for metabolic functions can be supplied as amino acids which are normal constituents of the blood stream.

Oral administration of amino acids should be effective. Among the chief disadvantages of the oral administration of amino acids are the very objectionable taste and odor. These may be partially covered by chilling and adding fruit juices but at best they are still objectionable.

in most instances. However, in those instances in which oral administration is contraindicated or there is a poorly functioning bowel, amino acids may be administered intravenously. Considerable care must be exercised in the intravenous administration of the amino acids. Severe reactions have been reported occasionally. It might be well to point out the advisability of very thorough cleaning of intravenous equipment following the use of amino acids. Unless very thoroughly cleaned, a pyrogenic reaction is likely to occur the next time the intravenous set is used.

Amino acids themselves are not used in supportive measures as for instance in cases of shock, but primarily in those cases in which the patient needs proteins. It must be remembered that amino acids must be given over relatively long periods to get desired results of increased blood proteins and so forth.

**Hemoglobin Solutions.**—Hemoglobin dissolved in Ringer-Locke solution, in plasma or in whole blood, diluted with sodium chloride solution can be made to give solutions with the same osmotic index as blood. Hemoglobin differs from other blood substitutes or plasma in being an oxygen carrier and also in being able to stimulate a rise of blood pressure. Certain investigators feel that hemoglobin in Ringer's solution is superior to acacia and saline solutions, but inferior to plasma or serum.<sup>8</sup> These solutions are still in the experimental stage.

**Whole Citrated Blood.**—The value of this therapeutic agent was well known before the start of the present war. In 1909 Crile<sup>13</sup> made the statement that, "judiciously employed, transfusions would surely prove a valuable, often life-saving, resource; injudiciously employed, it would surely become discredited." The experiences gained in this war have proved more conclusively that the use of whole citrated blood cannot be replaced entirely by that of other substances in certain conditions—namely, very severe loss of blood either in accidents or in operations, and also secondary anemia before or after operation, and in certain other medical cases. The therapeutic value of the erythrocyte is closely related to its function. It is a well-known fact that the condition of an otherwise healthy person does not become critical from slow or repeated hemorrhages until the erythrocytes have been reduced to about a third of normal. This does not hold true for sudden severe losses of blood. If the erythrocytes and hemoglobin have been reduced to less than 50 per cent, the transfusions of whole citrated blood represent the method of choice for raising blood volume and aiding adequate circulation.

The present-day "blood bank" is being widely appreciated. The present-day system of having lists of professional donors who are willing to donate blood at periodic intervals is very useful. In a recent survey of the professional donor list at the Mayo Clinic, we found forty-five donors who had had fifty or more withdrawals of blood. Ten of these had given more than 100 donations and one donor had

had 170 withdrawals of blood during the twenty-five years that he had been on the donor list. After stopping these periodic withdrawals the donors seem to adjust the hemopoietic power very readily and a polycythemic condition does not develop. The use of sodium citrate as an anticoagulant allows the storage of blood up to ten days. The use of DeGowin's solution permits the storage of blood up to thirty days. The great disadvantage of this solution is the large total volume of mixture of blood and solution that must be administered to get the value of the blood. In any or all solutions hemolysis is minimal for five days, after which it commences and is progressive. There are certain other solutions that may be used in like manner. Briefly there are certain rational indications for the use of blood: (1) to increase the volume of circulating blood, (2) to increase oxygen carrying power of blood, (3) to increase protein content of blood, (4) to increase coagulability of blood, (5) to stimulate hemopoiesis or (6) to add immunologic factors.

**Resuspended Red Cells**—There are certain cases in which the primary need is an increase in the erythrocyte count and not necessarily blood plasma. In this condition the erythrocytes left after the withdrawal of the blood plasma may be used. They have been transfused into patients both in thick concentrated form and diluted with an amount of saline or glucose solution equal to the plasma previously withdrawn. This problem will require further investigation.<sup>21</sup> Taylor, Thalheimer and Cooksey<sup>30</sup> have reported on the development of a program whereby resuspended blood cells are distributed to various institutions to be used for patients whose primary need is blood cells and not necessarily blood plasma and cells combined. The amount of cells given to a patient in twenty-four hours on occasion is extremely large. This method of transfusion is valuable in certain cases of cardiac disease in which it is undesirable to overload the cardiovascular system and yet it is advisable to increase the red blood cell count and hemoglobin of that patient. As far as the erythrocytes are concerned the blood cells from 500 c.c. of whole citrated blood will give the same benefit after the plasma has been withdrawn as will the original product. However, they should be administered within two to three days of the time of withdrawal and separation of plasma.

**Blood Plasma**—This can be stored in liquid, frozen or powdered form (fig. 340). In its liquid form it retains its value for the treatment of shock but storage does produce a loss of prothrombin, fibrinogen, complement and antibodies. Frozen plasma retains these properties lost by liquid storage but one of the disadvantages is the necessity of time in thawing out the frozen plasma. Dried powdered plasma retains these properties also but requires distilled water to dissolve it into a usable form. The injected proteins do not readily pass through the kidney. Thus they do increase the body reservoir of plasma proteins and because they do not readily pass through the capillary walls, the

circulating plasma is also increased. The albuminous portion of plasma comprises about 60 per cent of the plasma proteins but it is responsible for 80 per cent of the osmotic efficiency of the plasma. Work is being done using the albuminous part alone as a substitute. The concentration of the solution can be varied. Its main function is to draw water into the blood stream, by so doing it increases blood volume which is valuable in shock. Besides this advantage because it is low in salt it is valuable as a diuretic agent.

The globulin portion of plasma comprises about 10 per cent of plasma proteins. The globulin factor is important in the study and treatment of infectious diseases.

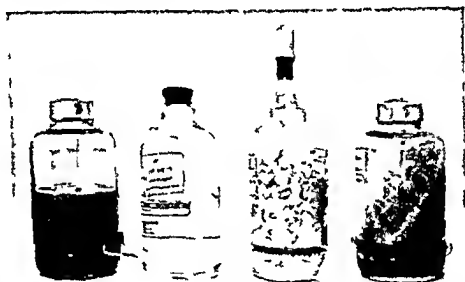


Fig. 340—The three forms in which plasma may be stored—liquid, powdered and frozen. The bottle second from the left contains distilled water which is used to dissolve powdered plasma.

**Bovine Plasma and Albumin**—Wangenstein and his associates<sup>34</sup> and Kremen and his associates<sup>18</sup> have reported the intravenous administration of bovine plasma and serum to man. A number of their patients experienced reactions of varying types and degrees. They found that if the hemolysins and hemoagglutinins were removed by human erythrocytes the reactions decreased from 66.4 per cent to 24.4 per cent.

Janeway and Beeson<sup>37</sup> found that beef albumin maintained blood volume and circulation of dogs in burn shock. When ten human subjects were tested an untoward reaction developed in only one case and in this case serum sickness previously had developed from horse serum. Evidence already accumulated indicates the possibility that properly purified bovine albumin will be a valuable therapeutic agent. When bovine plasma or serum is given certain possible dangers must

be remembered—the animal plasma or serum may contain hemolysins or hemoagglutinins which affect human erythrocytes. If the patient is susceptible to that particular animal protein he may experience a very severe reaction and it must be remembered that all such serum is antigenic in nature.

**Dried Blood Cell Powder**—This has been used as a dressing material in more than 200 cases at the Clinic. The cells left after the withdrawal of plasma from centrifuged whole citrated blood are dried in a process similar to that used for drying blood plasma. The powder has been used to advantage in certain cases of indolent ulcers seen on the vascular service, certain postoperative wounds which have broken down and are healing slowly, amputation stumps, skin grafts which are healing more slowly than expected and so on. The powder is dusted on these noninfected wounds daily. Serous or mucous discharges are removed at each dressing. When a scab from the application of dry cells forms after a few days dressings it is not removed unless there is a mucoserous discharge under it. It is felt that more investigation should be done. At the present time Barker and I are investigating the possibility of substituting dry bovine blood cells for human blood cells.<sup>5</sup>

#### APPARATUS

It has always been the practice of the Clinic to keep its equipment at as minimal an amount as is practical for the work to be done. As a consequence the apparatus used for the withdrawal of blood, storage and administration of blood, the preparation of blood plasma and the administration of fluids and so forth is as simple and practical as possible.

**Withdrawal of Blood**—Until recent months all whole citrated blood was collected in open mouthed bottles containing 75 c.c. of 2.5 per cent solution of sodium citrate (fig. 341). The bottles were suitably capped and stored in the refrigerator at 5° C. This proved to be economical as the containers after proper cleansing could be used again. The only parts necessary to replace were the rubber corks and broken glass breather tubes. However recently we have gradually switched from these open mouthed flasks to commercially purchased bottles. These bottles contain a vacuum and are suitably sealed. When the one top is removed a sterile surface on the cork is presented (fig. 342). The bottle contains 50 c.c. of 4 per cent solution of sodium citrate which is sufficient to prevent the clotting of 500 c.c. of whole blood. Before the special vacoliter valve needle is pushed through the rubber cork the inside of the bottle is thoroughly dampened with sodium citrate by shaking the bottle well. If this is done the blood entering the bottle and touching the sides of the bottle does not become hemolyzed.

The tourniquet that is used is an ordinary blood pressure cuff. To find the level of pressure that must be maintained in the cuff we read

the systolic and diastolic blood pressures of the donor and then keep our blood pressure cuff inflated to the half way mark between the systolic and diastolic blood pressure of that donor. It has been our impression that the use of the blood pressure cuff has proved helpful in that we are able to keep a more constant control over the tourniquet effecting the pressure necessary to afford a good flow of blood from that donor. If the donor's blood pressure suddenly drops and he becomes faint, the fact is immediately registered on the blood pressure dial or if the blood being withdrawn suddenly slows down its rate, we can immediately change the pressure within the blood pressure cuff.



Fig 341—Blood being collected in open mouthed flask by gravity method. Tourniquet used is a blood pressure cuff inflated to approximately 40 to 50 mm of pressure.

itself. All in all, we have found that the blood pressure cuff used as a tourniquet is more satisfactory than a rubber band or tubing surrounding the donor's arm.

The rate of flow can also be regulated by means of the vacoliter valve. The large valve needle passes through the rubber cork in the bottle. The tightness of the valve is always tested before the flow of blood is started by inverting the blood bottle so that the citrate is lying over the cork of the bottle and the valve needle is immersed in sodium citrate. If the valve has any leaks bubbles will appear in the sodium citrate solution. When the blood is running satisfactorily, a



constant agitation of the bottle is carried out throughout the withdrawal of the 500 c.c. of blood. By so doing the blood is thoroughly mixed with the sodium citrate. After the bottle of blood has been properly labeled it is placed in the refrigerator for future use. The temperature of the commercial refrigerator is kept as nearly as possible at 5° C. Once the blood has become chilled, the constant opening and closing of the refrigerator door have relatively little effect on the temperature of the bottle of chilled blood (fig. 343).

As a means of identifying the bottles of blood of various groupings we have specially marked labels which are attached to the bottles im-

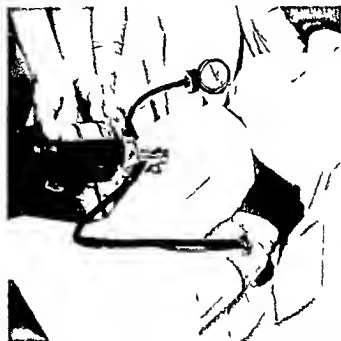


Fig. 342—Blood being drawn into vacuum bottles. Bottles contain 50 c.c. of 4 per cent solution of sodium citrate which is sufficient to prevent coagulation of 500 c.c. of blood.

mediately after the withdrawal of blood. These labels are marked with very large colored letters. Appropriate information about the donor is also on the label, for instance, the name, date of withdrawal and so forth. Labels designating group A blood have a large red "A" on the label. Group B blood is designated by a large blue "B". Group AB labels have a large red "A" and a large blue "B" and group O blood is designated by a large green "O" on its label. With these particular labels it is very easy to recognize the bottles of different blood groups at a considerable distance.

**Warming of Blood**—It has been the practice of the Clinic to take the

chill off the refrigerated blood before use if there is adequate time to do so. For this purpose we have a water bath which is regulated to 35° C. (fig. 344). Before a bottle of blood is placed in this warming bath, it is thoroughly shaken. After being placed in this water bath it takes only about twenty minutes to get the whole bottle warmed up to almost body temperature. In the event that we have not adequate



Fig. 343.—The storage of blood in a commercial refrigerator. The labels are well marked with large colored figures of A, B, AB and O. We always keep in storage some group O, Rh negative blood.

time to warm the blood before administration, a metal hot water bottle has been devised<sup>26</sup> (fig. 345, *a* and *b*). The water is placed in the two halves of the water bottle and the rubber tubing carrying the blood is placed between the two halves of the metal bottle. This has been very useful at times in taking the extreme chill off the blood. This is important as very chilled blood sometimes will cause marked vasoconstriction of the vein in the patient's arm or leg. This marked vasocon-

striction prevents the rapid administration of the blood. Sometimes this is undesirable as it is imperative that this blood be got into the patient rapidly, as in such cases as marked shock, severe hemorrhage and so forth.

**Apparatus for the Actual Administration of Blood.**—The set that is used for the actual administration of the blood is similar to the apparatus used in administering all intravenous fluids throughout the institution. It is composed of a glass dripper, rubber tubing, a metal clamp to regulate the speed of flow of blood and a Lewisohn needle of either 15 or 18 gage. It is not the practice at the Clinic to use filters in the actual administration set when blood is used (fig. 346, *a* and *b*). However,

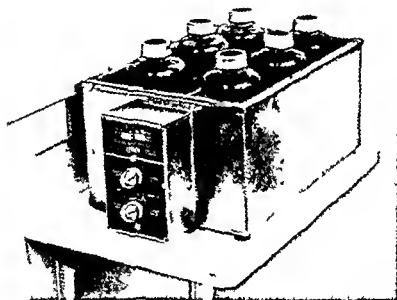


Fig. 344 Water bath for warming chilled blood. Temperature is automatically kept at 35° C.

this does not hold true when plasma is being administered. We do incorporate within the glass dripper a fine wire meshed filter to remove the fibrin clots that frequently are seen in the liquid blood plasma. All plasma whether processed in our own institution or purchased from a commercial firm is filtered before administration (fig. 347).

The needles used in the operating room are usually 15 gage Lewisohn needles. An 18 gage needle is used if a 15 gage needle is too difficult to get into a vein (fig. 348). In those cases in which we feel that the patient may need intravenous fluids, blood or plasma, occasionally we will place a 15 or 18 gage Lewisohn needle into the vein.

and have an obturator within the needle itself. At any time during the operative procedure that it is necessary to add intravenous medication

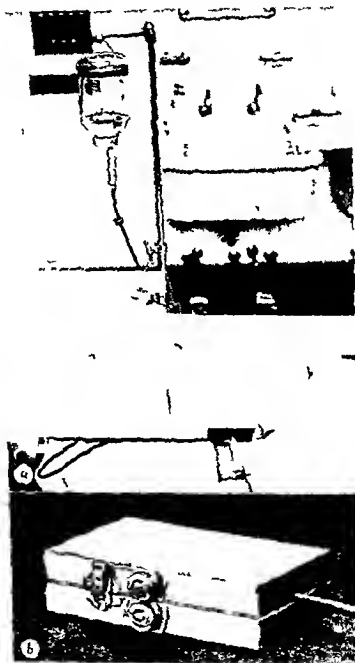


Fig. 34.—*a* Metal hot water bottle hanging from a standard—the intravenous tubing passes between the two halves of the bottle. *b* Close up of the hot water bottle.

this can be done relatively easily by removing the obturator and attaching the intravenous tubing or a syringe to the needle.

In certain cases it is desirable to administer blood relatively rapidly

and if it is impossible to get a 15 gage needle into the lumen of the vein, it is difficult to administer blood to the patient through an 18 gage needle. Adams<sup>1</sup> has devised a piece of apparatus whereby the pressure within a blood bottle can be increased. By this means the blood is forced from the bottle into the patient as rapidly as is needed (fig 349)

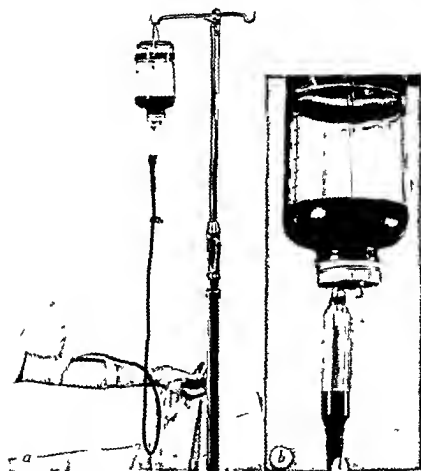


Fig 346.—a, The intravenous set used for administration of blood. b, Close up view showing dripper with no filter. The blunt needle on the right side perforates the cork to allow air to enter the breather tube.

For the transfusion of blood into small infants and children, Baird<sup>2</sup> has devised a piece of apparatus by means of which we can use a Record syringe somewhat similar to a pump. By means of a three way valve, blood can be sucked from a bottle into a syringe, the valve turned in the right direction and the blood forced through a small tubing into the vein of the patient (fig 350)

If the patient is a very small infant or if there is not adequate help to hold the small patient, we have found the multiple syringe method of administering whole citrated blood very useful. When a small needle is placed within a blood vessel, a very small tube connects the needle to a syringe, and simply by changing the syringe one can add as many syringe-fuls as are required by the small patient (fig. 351).

In the event that none of these apparatuses are available, Lundy and Rogers<sup>20</sup> have devised a roller which can be used to force blood along

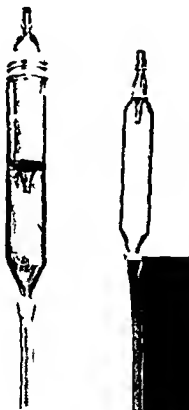


Fig. 347—The drippers which are in the intravenous sets and are used for the administration of whole citrated blood. The dripper on the right contains a fine metal mesh strainer.

by means of a rubber tubing. This roller has proved very valuable and by its use blood can be forced into a patient relatively easily and rapidly (fig. 352, *a* and *b*).

Occasionally it is difficult to place a needle within a vein of an adult, child or infant, and in such a case the various kinds of fluids—plasma, serum or whole blood—can be administered into one of the bone marrow spaces of the sternum or femurs or tibias. In small children or infants it is a relatively difficult procedure to get a bone marrow needle into the sternum because the space in a small sternum is rela-

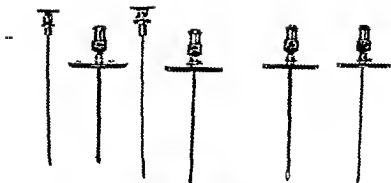


Fig. 348

Fig. 348—The ordinary 15 and 18 gage Lewisohn needles are on the right. The 15 and 18 gage Lewisohn needles on the left also have obturators which fix them accurately. The two needles can be brought within the vein and with the obturator do not leak blood. The obturators are removed when intravenous administration of fluids is started.

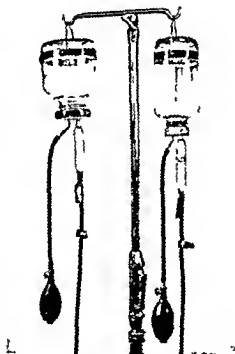


Fig. 349—Adams pressure apparatus for the administration of blood. The one on the left is for the open mouthed flask and the one on the right is the one used for the vacuum bottles.

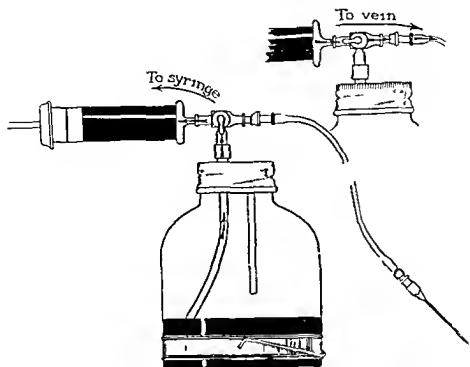


Fig 350—Baird's transfusion set to facilitate the administration of blood to small children and infants



Fig 351—The multiple syringe method of administering blood to small children and infants

tively difficult to enter. However, this is not true for adults and older children. Various kinds and makes of bone marrow needles are available commercially. At the Clinic we have no particular preference as



far as needles are concerned. Regardless of the needle that is used, the most important point is that the actual procedure of getting the needle into the bone marrow space of the sternum or tibia be carried out successfully.



Fig. 332-4, A close up view of the Lundy roller which is used for forcing paracental solutions through small needles. b How the roller is used on intravenous tubing.

If the sternum is chosen, the point of entrance of the needle should be approximately the same distance below the angle of Louis as the angle of Louis is from the suprasternal notch. After suitable preparation of the skin and after a local anesthetic such as metycaine or procaine hydrochloride has been injected into the tissues, a sternal needle is pushed into the skin at right angles until it contacts the anterior

surface of the sternum itself. Pointing the needle cephalad at a 45 degree angle, the needle is forced through the anterior plate of the sternum. As it enters the bone marrow space itself, a distinct sensation is felt. The feeling is similar to that of a needle passing into any open space and not meeting resistance. During this actual passage of the needle through the anterior plate of bone, a rotary clockwise and counterclockwise motion of the wrist and hand is made, the bevel of the needle always facing the bone marrow space itself. After the needle has entered the bone marrow space, it should be given a complete half turn so that its bevel is facing cephalad. If the bevel is left facing the bone marrow space, it may impinge on the anterior surface of the posterior plate of the sternum, thus impeding the inflow of whichever fluid, blood or plasma is being given (fig. 338).

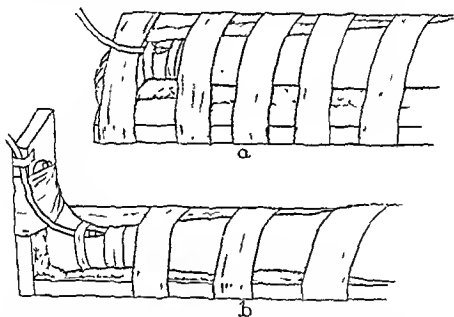


Fig. 353.—Splints as used on an infant's arms and legs to maintain a position for holding the child quiet to prevent the needles from coming out of veins.

In small children or infants we have found it to our advantage to use the anteromedial aspect of the tibia. The point between the upper and middle thirds of the shaft is where our local injection of 1 per cent solution of metycaine is made. The needle is forced through the plate of bone in a manner similar to that when the sternum is used. After the needle has entered the bone marrow space, the bevel is turned toward the knee joint itself. If the shaft of the femur is chosen as the site of injection of fluid, blood or plasma, then one uses that spot approximately one third of the way up the shaft of the bone. Again the actual entrance of the needle and the placing of the bevel are done similarly to that in the two previous instances (see fig. 339).

It is frequently advisable to splint the arms or legs of small children

and infants during an actual transfusion particularly if the transfusion is to be followed by a slow drip of one of the intravenously administered fluids (fig. 353). On occasion we use the same needle for three to four days of continuous fluid administration. When a leg or arm is suitably padded and suitably splinted, there is no particular discomfort to the patient. However, one must be careful that the sharp point of the needle is within the lumen of the vessel and not partially piercing the vessel wall. In the latter case there will be a constant sharp stinging sensation and almost inevitably the patient will complain of this pain. The less trauma that is made to the vessel wall the less likelihood there is of phlebitis or thrombosis from the actual traumatic entrance of the needle and the trauma caused by the presence of the needle within the vessel for a few hours or days.

The equipment used for the parenteral administration of fluids is similar to the equipment for the actual administration of whole citrated blood. The fluid administered intravenously at the Clinic is usually purchased from a commercial firm. The actual administration is done using a glass dripper tubing and an 18 gage Lewisohn needle. If the patient's veins are difficult to enter with a needle, occasionally we use a straight needle without a guard. However, it is the usual practice to use the Lewisohn needles with guards. The guards on the needles give the person who is administering the liquid a good hold on the needles and also facilitate the fastening of the needles in place by means of adhesive strips (fig. 337).

#### SUMMARY

The rationale of fluid therapy is simple in its basic principles. Saline solutions with or without glucose are valuable. The amount of sodium chloride administered per twenty four hours should not exceed 10 gm. Glucose, amino acids and vitamins all may play important roles in the care of patients. Plasma or serum helps out low serum protein states and helps restore blood volume with subsequent good results that one would hope to get. Acacia, pectin and gelatin solutions are valuable as plasma substitutes. If plasma or blood is indicated then one or the other of these should be given in preference to the substitutes.

Ordinarily 500 c.c. of fluids may be administered intravenously per hour, if conditions indicate that more rapid administration is warranted, then this should be done and the condition of the patient closely watched. As an average we take forty minutes to administer 500 cc. of whole citrated blood. If a more rapid administration is indicated we do not hesitate to run the blood in more rapidly.

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## THE USE OF PENICILLIN MIXED WITH A LOCAL ANESTHETIC

JOHN S. LUNDY AND ARNOLD E. OSTERBERG

THE injection of local anesthetic agents into traumatized or infected tissues has long been avoided and little effort has been made to extend the use of local anesthesia into such a field. Under ordinary circumstances it has been customary to use a local anesthetic solution that was sterile and a needle and syringe that were sterile and to prepare the skin properly. Under these circumstances infection usually did not occur but there the effort to use a local anesthetic agent rested.

Early in 1943 it occurred to one of us (J.S.L.) that some penicillin could be dissolved in the same fluid as the local anesthetic. Those who knew about penicillin were sure that it should be harmless when used in this way.

The following solutions were tested for their bacteriostatic power by F. R. Heilman: 250 Oxford units of penicillin sodium per milliliter with and without 0.5 per cent procaine and with and without 0.5 per cent metycaine, 250 Oxford units of penicillin sodium per milliliter with and without 0.5 per cent procaine and with and without 0.5 per cent metycaine. It was clear that the procaine or metycaine did not destroy the antibacterial properties of penicillin.

In order to demonstrate that the penicillin did not interfere with the production of anesthesia, one of us (A.E.O.) prepared a solution in water containing 250 Oxford units of sodium penicillin per cubic centimeter and this was supplied to the operating room supervisors in 100 c.c. bottles. These bottles were kept in the refrigerator. An hour or two before they were to be used, they were taken out and brought to room temperature. The supply on hand never was more than enough to last for three or four days. This relatively fresh preparation was used with procaine or metycaine. A small amount of epinephrine was added, as is our standard practice, in all cases except those in which epinephrine was contraindicated. In a few instances an ampule containing 25,000 Oxford units of calcium penicillin was placed on the standard tray for local anesthesia. It was then possible to have a really fresh preparation at any time by simply adding the penicillin when the local anesthetic solution was prepared just before injection, which was our routine custom.

The injection of this material was carried out in connection with sacral block for hemorrhoidectomy and it has been utilized in a series of cases. Anesthesia and relaxation were produced and it seemed to be clear that this was a usable mixture. It also has been used in continuous caudal anesthesia in obstetrics, abdominal and field blocks, and in

consilectomy and dental procedures. It seems clear that the use of penicillin with a local anesthetic agent is practical.

Two cases are of special interest. In these two cases in which sacral block was used as the anesthetic method in performance of hemorrhoidectomy and penicillin was given in the anesthetic solution, urticarial spots developed where the skin wheals had been raised over the sacral hiatus and over the second third and fourth sacral foramina bilaterally. One patient knew definitely that he was sensitive to celery. The other patient, a physician, was in general fairly sensitive to many things but was not definitely allergic as far as he knew. These two patients were examined by the dermatologists. The physician was tested for sensitivity to various combinations of the mixture and reacted positively to the metycaine. No untoward systemic result was noticed by the patients or attending physicians. Only the little spots in the skin were observed and yet 60 to 70 c.c. of 1 per cent metycaine in the penicillin water with epinephrine was used.

Four months after the operation the physician received penicillin again, this time it was given intramuscularly. Shortly thereafter urticarial spots developed at the site of the former skin wheals over the sacrum. There was marked edema of the skin as well, particularly of the face and ankles. The process subsided within a period of two weeks with diffuse desquamation. It seems likely that the penicillin given at the time of the operation had served to sensitize the tissues in this vicinity to penicillin. When penicillin was injected subsequently, it traveled through the blood and produced a focal reaction of dermatitis over the sacrum. Doubtless the patch test on this patient if it were made, would reveal sensitivity to penicillin.

The sensitivity to penicillin will preclude the patient's further use of penicillin as long as there is no practical method of desensitization.

The use of penicillin gives one some hope of protection against certain gram positive organisms and one or two gram negative ones. Now that it has become more available to the public its prophylactic use may be indicated.

This report is published with the idea of calling attention to the possibility that in some cases the combination of an antibacterial agent with a local anesthetic agent might be useful. However, apparently there is no reason at present to believe that it should be used routinely wherever a local anesthetic agent is to be used. The possibility that some patients will be skin sensitive to penicillin is shown by one of the cases mentioned.

A study of the usefulness of combining one or more antibacterial agents with a local anesthetic might very well add to the field of usefulness of local anesthetics.

## ATELECTASIS

LLOYD H. MOUSEL\*

MANY hypotheses have been advanced to explain the etiologic factors involved in the production of atelectasis. Enough obstruction might be produced by edema of the mucous membranes, similar to angioneurotic edema to cause pulmonary collapse. Bronchial spasm has been suggested as a possible cause of atelectasis, but bronchial spasm usually produces the antithetic condition, that is, emphysema with bilateral distribution. The "vasomotor theory" suggests that dilatation and stasis in the blood vessels might produce obstruction in the bronchioles by an outpouring of secretion. In my opinion postoperative atelectasis is caused by mechanical obstruction in most cases, that is, actual plugging of a bronchus or several bronchi by tenacious secretions which have collected in the tracheobronchial tree during anesthesia, by mucopurulent material which was present preoperatively, or by mucus, blood or vomitus which has been aspirated into the trachea either during or immediately after anesthesia.<sup>3</sup>

Atelectasis may begin gradually or suddenly. The bronchus becomes plugged and preliminary emphysema results. If this plug is not removed by aspiration or if the patient is unable to remove the plug by coughing or by change of position, the air in the involved region will be absorbed into the blood stream until pulmonary collapse is complete.<sup>1</sup> Atelectasis may develop suddenly if the patient has been breathing highly absorbable gases such as those which compose the anesthetic mixtures. If a large amount of nitrogen is present in the lung at the time of bronchial occlusion, absorption of the gas will be sufficiently slow to delay complete collapse of the lung for many hours.

The symptoms and signs of postoperative atelectasis usually follow a rather definite pattern. The patient complains of dyspnea, which frequently is out of proportion to the degree of pulmonary involvement present. He feels discomfort over the lung involved, the pulse becomes rapid, temperature increases suddenly and cyanosis becomes apparent, the degree of cyanosis depends on the amount of pulmonary tissue involved. Breath sounds become diminished or absent. In the presence of massive atelectasis the heart and mediastinal structures are shifted toward the side involved and the respiratory excursion on the affected side becomes diminished.

### PREVENTION

If the incidence of postoperative atelectasis is to be reduced, many details must be attended to before and during anesthesia as well as after

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operation. Preoperative medication may have an effect on the development of pulmonary complications. Heavy smokers, patients suffering from chronic sinusitis and patients suffering from chronic pulmonary or respiratory infections of any kind routinely spend considerable time clearing their nasopharynx and tracheobronchial tree of the accumulated secretions immediately after arising from bed after a night's sleep. Heavy smokers almost always have some tenacious mucus in their air passages. Patients who receive a sedative in the evening often awaken in the morning in a somewhat stuporous condition. Their reflexes have been dulled by the action of the sedative. Additional sedatives usually are administered early in the morning and produce a restful sleep. As a result the patient has had no chance or urge to clear his airway of the secretions which have accumulated during the night. It might be well to place the patient in a vertical position and encourage him to clear his nasopharynx and tracheobronchial tree before any sedative is administered in the morning. In this way much offending material might be removed.<sup>4</sup>

Atropine or scopolamine reduces the amount of salivary secretion during induction of anesthesia and no doubt use of one or the other makes possible a much smoother induction than could be obtained otherwise. However these drugs may be responsible for the drying of secretions which are present until they become so tenacious that the ciliated epithelium is unable to move them up into the trachea.

A patient's stomach should be empty and care should be taken to be sure that no loose teeth or foreign bodies are present in the patient's mouth, for the aspiration of any foreign body is almost sure to produce atelectasis.

If there is any amount of secretion in the airway at the termination of anesthesia or if vomiting has occurred during anesthesia and any of the material has been drawn into the lungs, the pharynx, trachea and bronchi should be well aspirated before the patient is returned to his room. Tracheobronchial aspiration by direct vision through a bronchoscope, so that the bronchus of each lobe can be visualized and cleaned of any foreign material is probably best. After the patient has been returned to his room he should be encouraged to breathe deeply and cough and he should be turned from side to side at least every hour. Carbon dioxide inhalations should not be used for the violent respiratory effort incident to the administration of this gas tends to draw mucus and other foreign material deeper into the bronchus and thereby a more complete block of the airway to the collapsed segment of the lung is created.

During the first few hours after anesthesia, morphine and other sedative agents should be used sparingly so that the patient's reflexes may return to as nearly a normal state as possible. The patient should be turned frequently in bed and encouraged to breathe deeply and to cough.

## TREATMENT

**Conservative Measures**—In many instances conservative treatment of atelectasis will suffice. This treatment usually consists of frequent turning of the patient from side to side, encouraging the patient to cough, and to carry out deep breathing exercises. It is impossible to determine which patients will respond to conservative treatment and which will require bronchoscopic aspiration. I believe that conservative measures should not be employed for more than two hours after atelectasis develops. If the patient is not relieved of atelectasis within two hours by these measures, he should be given the benefit of bronchoscopic aspira-

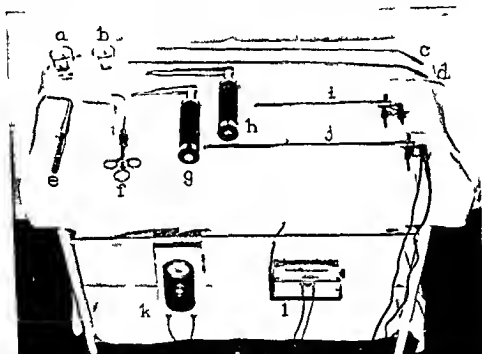


Fig 354—Instruments for bronchoscopy *a*, 5 per cent solution of cocaine, *b*, 20 per cent solution of cocaine, *c*, small aspirating tip, *d*, large aspirating tip, *e*, laryngeal forceps, *f*, laryngeal syringe, *g*, child's size laryngoscope, *h*, adult's size laryngoscope, *i*, child's size Negus bronchoscope, *j*, long adult's size Negus bronchoscope, *k*, battery rheostat, *l*, rheostat.

tion, for if aspiration is delayed longer, pneumonitis may develop. If ordinary conservative measures of treating atelectasis have been employed in an attempt to prevent atelectasis and have failed, it is obvious that these measures are not likely to relieve the condition; then and bronchoscopic aspiration should be instituted as soon as the condition is recognized.

**Bronchoscopy**—Bronchoscopy is carried out with the patient in the supine position—either on an operating table or cart, although on occasion it may be done with the patient in bed. Pledgets of cotton are grasped with a laryngeal forceps (fig 354). The pledgets are dipped

into a freshly prepared solution of 20 per cent cocaine. Excess solution is removed from the cotton by compression between the fingers. The patient's tongue is grasped and held forward with the fingers of the left hand. The cotton pledget is passed over the base of the tongue to the pyriform fossa, where it is held for about a half minute. The procedure is repeated on the opposite side. A pledget of cotton soaked in solution of cocaine is then placed in direct contact with the vocal cords. After the throat has been anesthetized 1 c.c. of a 5 per cent solution of cocaine is allowed to flow over the base of the patient's tongue and into the trachea. The patient is now moved toward the head of the operating table until his shoulders rest at the edge of the table. An assistant supports the head.

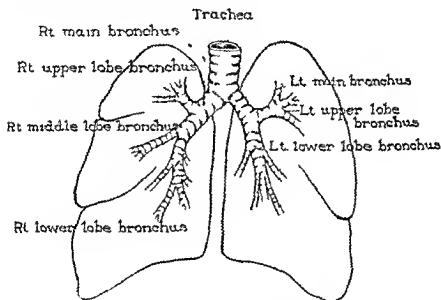


Fig. 355.—Diagram of tracheobronchial tree

A damp sponge is placed over the patient's upper teeth. A laryngoscope is passed beyond the base of the tongue until the epiglottis is visualized. The epiglottis is then raised with the tip of the laryngoscope. The bronchoscope is now passed through the laryngoscope into the trachea. After the bronchoscope has been passed into the trachea the laryngoscope is removed from the patient's mouth. One cubic centimeter of a 5 per cent solution of cocaine is placed in the bronchoscope and allowed to flow into the trachea. This cocaineization tends to diminish the cough reflex. The bronchoscope may now be maneuvered until the bronchus of each lobe has been visualized (fig. 355) and all secretion has been aspirated (fig. 356).

The patient should not be allowed to take food or liquids by mouth

for at least two hours after cocaineization of the throat, for the pharyngeal and laryngeal reflexes have been abolished and any attempt by the patient to swallow might result in the aspiration of fluid or food into the trachea. After bronchoscopy, the administration of oxygen is continued. The patient should be turned from side to side frequently and he should be encouraged to cough.

Two cases are presented to illustrate the results obtained by bronchoscopic aspiration.

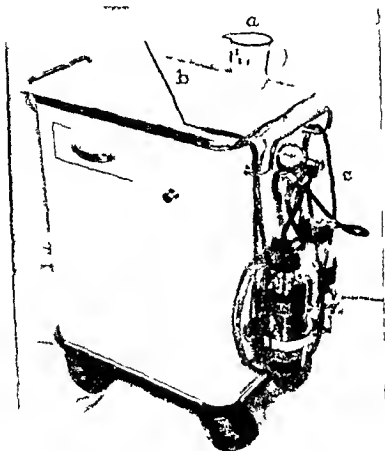


Fig. 556—Apparatus for aspiration. *a* cup containing water for irrigating tubing; *b* aspirating tip; and *c* vacuum bottles and control valve.

**CASE 1**—The patient, a man fifty-one years of age, had undergone pneumonectomy for carcinoma of the bronchus of the left lower lobe of the lung. Cyclopropane-oxygen anesthesia produced through an intratracheal tube was used for the operation and the patient was on his right side throughout the operation.

During most of the operation the condition of the patient was satisfactory. Some fluid collected in the trachea and intratracheal tube at about the time the hilar structures were being ligated. Contents of the intratracheal tube and trachea were aspirated frequently by means of a urethral catheter.

The patient became cyanotic during the last half hour of anesthesia. Cyanosis became marked after administration of the anesthetic gas and oxygen was dis-

continued. A high concentration of oxygen then was administered without relieving the cyanosis.

The first roentgenogram of the thorax made before the patient was removed from the operating room disclosed almost complete atelectasis of the right lung. Only a small portion of the base appeared to be expanded. The left part of the thorax was filled with air. The mediastinal structures were shifted to the right (fig. 357).

Immediately after the first postoperative roentgenogram had been made bronchoscopy was performed. The left main bronchus was found to be ligated approximately 2 cm from the carina. The bronchus of the lower lobe of the right lung was filled with thick bloody mucus; several blood clots were found in the right main bronchus and trachea. All visible foreign material was removed by aspiration.



Fig. 357 Atelectasis of the upper and middle lobes of the right lung with partial atelectasis of the lower lobe of the same lung.

A second roentgenogram made immediately after bronchoscopy, showed a large amount of air in the left portion of the thorax. The lower lobe of the right lung was expanded. The upper and at least a portion of the middle lobe of the right lung remained atelectatic (fig. 358). Bronchoscopy again was done. The trachea and right main bronchus appeared to be free of foreign material. A cough reflex was elicited by the presence of the bronchoscope in the trachea. After the patient had coughed bloody material could be seen coming from the bronchus of the upper and middle lobes of the lung. This material was removed by aspiration.

A third roentgenogram disclosed that the air in the left portion of the thorax had been evacuated. The mediastinal structures were approaching a normal position. The lower two thirds portion of the lung was expanded. Subcutaneous emphysema of some extent was present on the left (fig. 359).



Fig 358—Atelectasis of the upper and middle lobes of the right lung



Fig 359—Atelectasis of the upper lobe of the right lung with partial atelectasis of the middle lobe of the same lung. The mediastinal structures are approaching a normal position.



Fig 360—The right lung is almost completely expanded, although residual infiltration of some extent remains in the upper lobe of this lung



Fig 361—The right lung is well expanded, although small zones of residual infiltration remain

Bronchoscopy was carried out a third time. The cough reflex was rather active at this time. More bloody material was aspirated from the bronchi of the upper and middle lobes of the right lung. After bronchoscopy had been carried out for the third time, air could be heard coming in almost normally over the entire right side of the thorax. Cyanosis disappeared and the patient's color remained good.

A fourth roentgenogram disclosed the mediastinal structure to be on the left. The right lung was almost completely expanded, although residual infiltration of some extent was noted in the upper lobe (fig 360).

Forty-eight hours after operation the right lung appeared to be well expanded although small zones of residual infiltration remained (fig 361).

The patient's recovery was normal. A roentgenogram made on the nineteenth postoperative day showed the right lung to be completely clear (fig 362).



Fig 362—The right lung is completely clear

The value of direct vision bronchoscopy, with aspiration of the bronchus of each separate lobe is illustrated by this case. Aspiration by catheter of the patient's trachea was carried out frequently during the operation but atelectasis developed in spite of frequent aspiration.

CASE 2—The patient, a woman twenty six years of age, who had chronic infection of the upper part of the respiratory tract underwent appendectomy and cauterization of the cervix. Nitrous oxide-oxygen and ether anesthesia were employed for the operation. Anesthesia was uneventful. Twelve hours after operation the patient began to cough. Musical inspiratory rales were heard over the thorax, but the thorax was resonant throughout. Twenty four hours after operation the patient complained of pain low in the chest which was referred through to the back. At this time breath sounds were distant on the right, and the entire right side of the thorax was dull to percussion. Some bronchial breathing could be heard over the upper third of the right lung. The temperature at this time was



98.5° F (36.9° C). The patient became cyanotic. Roentgenologic examination of the thorax disclosed massive atelectasis of the right lung (fig 363, a). The patient was turned frequently from side to side, 5 per cent carbon dioxide and 95 per cent oxygen was administered at hourly intervals, and she was encouraged to cough. Cyanosis persisted, and on the second postoperative day the patient's temperature was 101.4° F (38.5° C), massive atelectasis was still present.

Bronchoscopic examination disclosed an inflammatory reaction around the bronchi of the middle and lower lobes of the right lung. A small amount of thick, tenacious mucus was aspirated from these bronchi. The bronchus of the lower lobe was edematous and almost completely closed. Gentle dilatation was carried out. After dilatation of the edematous portion of the bronchus a small tenacious plug of mucus could be seen. This plug was removed by aspiration. Four hours after bronchoscopy there was no dullness over the right side of the thorax (fig

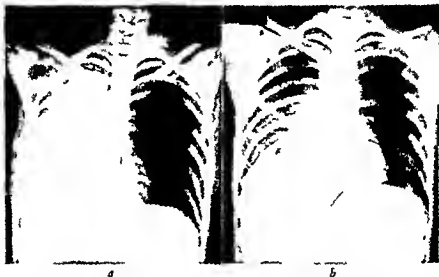


Fig 363—*a* Massive collapse of the right lung with a shifting of heart and mediastinal structures to the affected side. *b*, appearance four hours after bronchoscopic aspiration (Mousel JAMA 115 899-902 [Sept 14] 1940)

363, b). Fourteen hours after bronchoscopy there was evidence of consolidation in the lower lobe of the right lung; however, this condition rapidly disappeared and on the fifth postoperative day the thorax was clear and the body temperature receded to normal. Convalescence was uneventful.

In case 2 the ball valve action of the mucous plug which was found distal to the edematous mucous membrane in the bronchus of the lower lobe of the right lung was interesting for after aspiration, atelectasis apparently completely disappeared, but was present again fourteen hours after aspiration. I assume that the edema continued to obstruct the bronchus after aspiration and that atelectasis once more developed in the lower lobe of the right lung. However, the irritating mucous plug had been removed, so that the edema soon subsided and the lobe once more became filled with air.

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haps one of the most important observations in connection with pentothal anesthesia is that a patient's tolerance to the drug is lowered by traumatic and surgical shock, debility, toxemia and imitating conditions. This observation has been amply corroborated by its use in war casualties. When the physical state of a patient has been altered in this manner, the subanesthetic doses may become anesthetic and anesthetic doses may prove to be sublethal if not lethal. The use of pentothal need not be hazardous for such patients if its administration is modified to conform with their decreased tolerance to the drug. This simply means a dose of 1 c.c. (of a 2.5 per cent solution) must be given when ordinarily 4 or 6 c.c. might be used. It also means that a continuously free airway and adequate respiratory exchange must be assured for the patient since pentothal sodium may prove toxic in very small doses when only minor degrees of anoxia are present.

It often has been said that one of the advantages of intravenous anesthesia was that little or no equipment was necessary for its successful administration. Such statements are not only misleading but have resulted in many unfortunate experiences in the hands of those who believed them. The idea that general anesthesia produced by the intravenous administration of the anesthetic agent is fundamentally different from general anesthesia induced by inhalation or that it carries with it less possibility of untoward side effects is incorrect. This fact must be both understood and acknowledged by those who wish to employ intravenous anesthesia successfully. All of the difficulties associated with inhalation anesthesia are possible under intravenous anesthesia. These complications have to do chiefly with the airway, respiratory exchange and oxygenation of the patient. They need not be any more serious under intravenous anesthesia than under inhalation anesthesia provided the equipment for taking care of such difficulties is available.

Anesthetists who had used pentothal sodium extensively soon came to realize that such equipment must be at hand if intravenous anesthesia was to be administered with a degree of safety comparable to inhalation anesthesia. As a result, intravenous anesthesia with pentothal sodium is now managed much the same as inhalation anesthesia. The anesthesiologist should have available endotracheal tubes, oropharyngeal and nasopharyngeal airways, a laryngoscope, mouth props, suction

and so forth. The use of oxygen or oxygen and nitrous

oxide procedure from the beginning

with apparatus

so that one of the gases is used in the machine  
if pentothal anesthesia is not adequate or if too large doses are given, the patient can be removed from the machine  
large doses. These measures have provided a degree of control and flexibility that never was attained when pentothal sodium was used as the sole anesthetic. Flexibility also has been increased by using local

regional or spinal anesthesia as a supplement or complement to the intravenous method. These measures aid in the attainment of good relaxation in refractory cases and help to keep at a minimum the total dose of pentothal sodium. It is no reflection on the anesthetist's skill and ability if he feels it necessary to employ a supplementary agent with intravenous anesthesia. Rather it is an indication of his good judgment that he realizes the increased benefit and safety which such combinations afford in certain cases in which the risk is great or operations are difficult.

It is difficult and impractical to try to set down the operations for which intravenous anesthesia is most suitable. Intravenous anesthesia is not as suitable for certain operations as for others. In general the most unsuitable are extensive, intra abdominal, intrathoracic and intracranial operations, operations about the nasal, pharyngeal and laryngeal passages and operations in which the position of the patient or the nature of the lesion predisposes to respiratory obstruction. However, the use of special methods such as endotracheal intubation or supplemental regional anesthesia, may make intravenous anesthesia feasible and perhaps even desirable in some of these more extensive surgical interventions.

When choosing intravenous anesthesia the anesthetist must look ahead, as with other methods, to see whether or not it will provide all the control necessary for satisfactory working conditions for the surgeon and at the same time safety for the patient. If it meets these requirements, it makes little difference under what conditions the method might be considered for use, whether in civil or military practice, in cases in which the operative risk is good or poor or for any type of operation. The anesthetist should be able to evaluate the situation and decide whether or not intravenous anesthesia is a suitable choice. The advantages of pentothal sodium anesthesia are many. It should be used in such a way that its desirable features are always paramount.

## VENIPUNCTURE—A NEGLECTED SUBJECT

R. CHARLES ADAMS

ORDINARY every day routines in medical practice are often taken for granted. As a result the same mistakes and the same inefficiency persist day after day and year after year in many institutions. The technique of venipuncture is one of the most glaring examples.

If venipuncture were performed less frequently there might be an excuse for making it a minor issue; however in recent years the use of venipuncture for intravenous therapy and diagnostic procedures has increased so markedly that the present day surgical patient undergoes many venipunctures during the course of an ordinary illness. Whether or not these are performed quickly and without pain or whether the patient is tortured by multiple punctures makes a lot of difference to the patient particularly if he is very ill. One has only to talk to patients to be convinced of this fact. A few persons seem to be naturally adept at venipuncture but the majority have to be taught its intricacies before any degree of skill is attained. The fact that venipuncture generally is poorly performed may be the fault of those of us who teach the various branches of the practice of medicine. I am firmly convinced that the fundamentals of venipuncture should be a part of the practical instruction of medical students, internes and postgraduate students in the major fields of medicine. I do not hesitate to say that eight of ten newly graduated physicians will fumble venipuncture in a case in which the procedure is difficult. It is because of this that I feel that further stress on this important subject is not useless repetition.

Of course it goes without saying that venipuncture is not difficult in cases in which patients have large well filled superficial veins and even the novice usually has little difficulty in such cases. It is in cases in which the veins are small poorly filled or deeply placed or in infants or young children or in edematous patients or those who are in circulatory collapse that both skill and experience are required in order to perform venipuncture successfully.

The elements of successful venipuncture should include the minimum of pain for the patient, venipuncture on the first attempt and comfortable maintenance of the needle in the vein. The needle should be placed so that it cannot be easily dislodged from the vein. There is no substitute for practical experience in learning the fine points of venipuncture but much valuable information may be disseminated by describing the fundamental principles. I should like to offer some suggestions based on frequently repeated mistakes that should prove useful.

Many physicians do not take the time to evaluate fully the condi-

tion of a patient's veins before the puncture is attempted. Many satisfactory veins may be overlooked while searching for a vein at one of the so called standard sites for intravenous therapy. Another common failing, particularly when one is in a hurry, is to attempt venipuncture before the veins have been fully distended. A little time and care will correct these errors. When a patient has poor veins time will be well spent in evaluating the condition of the veins not only in the antecubital fossae but also in the ankles, feet, wrists, forearms and the backs of the hands. If the veins in all these sites appear to be equally satisfactory, a site should be chosen which will be as comfortable as possible for the patient and which will permit maintenance of needle within the lumen of the vein throughout the course of the injection or infusion.

If the veins appear to be unsatisfactory, one must take measures to insure their adequate filling before attempting to insert the needle. The time spent in working up poorly filled veins is well spent since an expert at venipuncture will no doubt have difficulty in getting the needle into a collapsed poorly filled vein. Several things may be done to render veins visible and well filled in cases in which no veins can be seen. A good tourniquet is essential if the veins are poor. It should be adjusted to the optimal tension and placed a short distance (about 15 inches) above the proposed site of venipuncture. This helps to provide adequate filling but if the tourniquet is placed close to the site of venipuncture it aids in fixing and stabilizing the vein and prevents it from rolling during insertion of the needle. If these measures are not sufficient to promote optimal filling, the extremity may be slapped, massaged or otherwise manipulated in order to increase the blood flow. It is amazing how such passive movements will distend poorly filled veins. In cases in which venipuncture is particularly difficult, moist heat, applied to the whole extremity for twenty to thirty minutes is one of the most important adjuncts.

The type of needle one uses is not as important as its caliber. Except in the case of infants and in cases in which venipuncture is unusually difficult, the needle should be not smaller than 18 gage since most types of fluids and blood will flow freely through an 18 gage needle and clotting within the lumen is less likely to occur than it is in a smaller needle. For supportive therapy in the operating room a 15 gage needle is preferred. If a wheal is raised with a local anesthetic solution such as a 1 per cent solution of procaine, prior to venipuncture, the procedure can be carried out painlessly. This detail in the technic takes only a little time and effort and is greatly appreciated by the patient. The point of the needle should be inserted into the lumen of the vein for at least one half inch to prevent its being dislodged.

These are a few of the preparatory measures I institute prior to venipuncture in cases in which the procedure is difficult. They take a little time but the time is well spent. It is indeed disgusting to see both

arms of a patient covered with puncture holes and blood, the patient exhausted and the interne blaming his trouble on poor equipment or an un-co operative patient or on anything but his lack of skill and poor technic. However, it is not entirely the student's fault, for few institutions go to the trouble of lining up a systematized course in venipuncture. There is no reason why the average physician, whether he be a general practitioner or specialist, should not be at least competent if not skillful in venipuncture. Certainly, intravenous medication is a part of every branch of medical practice and one should see that the details of its technic receive more attention than they have in past years.

## ENDOTRACHEAL OR INTRATRACHEAL ANESTHESIA

JOHN S LUNDY

THE endotracheal or intratracheal method of anesthesia has become one of the most valuable methods for increasing the number of cases in which use of inhalation anesthetic agents is satisfactory, for carrying out artificial respiration and for facilitating drainage of the lung. There are many methods from Flagg's for which a noncollapsible, flexible metal tube covered with a thin layer of rubber is used to the modern method for which the large bore soft rubber Magill intratracheal tube is used. This modern method is especially valuable because the large bore, modern intratracheal tube with or without a cuff provides the best possible airway for ventilation of the lungs.

The tube may be used simply as an airway, as it is when ether is administered by the semiopen drop method and when the gas machine is being used by the closed or semiclosed method with a gas mask. The intratracheal tube continues to provide the airway when it is connected to an adapter and the mask is not used. Another function is to provide the surgeon with an uncomplicated field for operation and one that can be rendered sterile and properly draped and may be so maintained throughout the operation. An advantage also is that the stomach usually will not become inflated as it sometimes does when a mask is used. This advantage is particularly evident when controlled respiration is used, that is, when the anesthetist presses intermittently on the bag to carry out ventilation of the lungs. This may be done either for the purpose of resuscitation or for the purpose of inducing and maintaining proper depth of anesthesia.

### BENEFITS DERIVED FROM INTRATRACHEAL TUBE AND INTRATRACHEAL ANESTHESIA

The physical aspects of respiration (fig 364) are responsible for the benefits derived from the large bore Magill intratracheal tube. Breathing requires a certain muscular power in order to force air or gases through the respiratory passages. The smaller the passages the more power required whether the narrowness of the passages is due to immaturity (infants and children) or to some obstruction which tends to collapse or narrow the air passages as, for example, the pressure of a large substernal goiter or intrathoracic tumor on the trachea. An intratracheal tube overcomes the narrowing caused by obstruction to some extent and permits the exchange of air or gases with minimal respiratory effort on the part of the patient. Quiet breathing thus obtained facilitates operation in many cases by bringing about a relatively motionless operative field, especially in the abdomen, by decreasing the muscular effort without increasing the depth of anesthesia. In some



cases satisfactory anesthesia and relaxation occur soon after the tube allows the anesthetic agent to enter the lungs in effective doses. The introduction of the intratracheal tube facilitates to and fro respiration by separating the vocal cords on inspiration as well as on expiration and permits insufflation of air, gases, oxygen or mixtures when artificial respiration may be necessary.

An intratracheal tube provides (1) a means of introducing an adequate dose of the anesthetic agent more easily, (2) an unobstructed operative field, (3) placid and adequate respiration, (4) an effective means for carrying out artificial respiration, (5) a means for preventing aspiration of foreign material and (6) a respiratory stimulant. Several of these points will be considered in more detail.

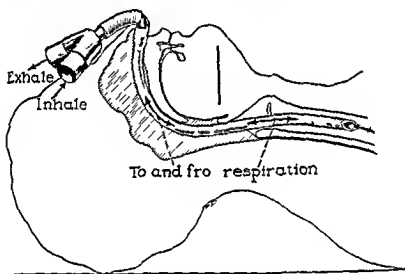


Fig. 364—Intratracheal tube in place with special adapters attached to it for connection with the gas machine.

**Facilitation of the Introduction of an Adequate Dose of the Anesthetic Agent**—For the ordinary patient a greater volume of anesthetic agent is inhaled into the lungs with a given muscular effort when the Magill intratracheal tube is used than when it is not used. It is especially effective in those cases in which respiratory obstruction from any cause, such as laryngeal spasm, obstruction from the tongue or inhalation of mucus fluids or foreign bodies, tends to develop. Although this effect may not be as noticeable when such a potent anesthetic agent as ether is used in an ordinary case, the advantage of an intratracheal tube in the administration of a weak anesthetic agent such as nitrous oxide, is particularly apparent for dental operations. In these cases if the intratracheal tube has been properly placed air can be excluded effectively from the lungs so that most dental patients

can be anesthetized satisfactorily with a mixture of 90 per cent nitrous oxide and 10 per cent oxygen without the addition of ether. Preliminary medication increases the number of cases in which this is possible. The tube facilitates anesthesia when fireproof conditions must be maintained and the operation requires that the face, mouth and throat be accessible to the surgeon as, for example, for cauterization of lesions of the tongue or pharynx. For this procedure a combination of perhaps 70 to 80 per cent or more of nitrous oxide and 30 to 20 per cent or less of oxygen is used through an intratracheal tube and comparatively small doses of pentothal sodium are administered intravenously.

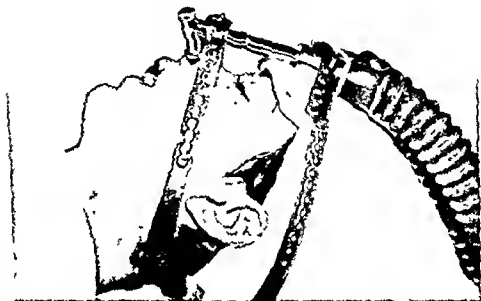


Fig 365—The connector in place following intratracheal intubation by the nasal route. Note the absence of any adhesive tape about the patient's head or on the connector and also the screw cap which covers the opening through which a flexible rubber catheter can be inserted down the intratracheal tube for purposes of aspiration.

If the flow of gas from the machine is of sufficient volume and is under sufficient pressure, air will be largely excluded from the lungs even though the tube does not fit the trachea tightly. The current of nitrous oxide and oxygen in the trachea and escaping around the tube is sufficient to exclude most of the air that would otherwise be inhaled around the tube. When a potent anesthetic agent such as ether is administered and the intratracheal tube is used as an airway only, the patient is able to inhale a high percentage of the ether that is dispensed. When the tube is not used, relatively large quantities of ether must be offered to the patient since he will be able to accept only small amounts of it at each inspiration.

Occasionally when the tube is not in place and sometimes when it is,

the patient cannot inhale the anesthetic agent because reflexly he holds his breath (too lightly anesthetized) or because the combined effect of preliminary medication and general anesthesia is enough to stop respiration but does not produce surgical relaxation. Under such circumstances it is possible to administer the agent to the patient through an intratracheal tube by intermittent positive pressure on the bag. This can be done by using the intratracheal tube as an airway and applying the mask to the face. By this method, however, the stomach as well as the lungs frequently becomes inflated. If the intratracheal tube is connected to a gas machine with an adapter so that the positive pressure on the bag inflates only the lungs but does not force the gas through the esophagus the agent can be administered in a way to produce satisfactory results.

**Unobstructed Operative Field**—An intratracheal tube can be introduced into the trachea and connected to the gas machine or to another device for administering an anesthetic agent by inhalation. The connection can be placed so that it does not interfere with the operative procedure and is particularly useful for operations about the face, neck, and head (fig. 365). It is possible to provide a sterile field for such operations, for the intratracheal device or devices can be covered with a sterile towel and, in addition, they can be sterilized. The convenience of such an arrangement is illustrated by the following two cases.

An elderly woman because of extreme nervousness could not co-operate with the surgeon for removal of a mature cataract even though preliminary medication had been used as well as a local anesthetic agent. It was necessary to employ general inhalation anesthesia for the operation because at that time the present intravenous anesthetic agents were not available. Nitrous oxide, oxygen, and a small amount of ether were administered through an intratracheal tube and excellent results were obtained. The surgeon was well pleased and the operation was successful which it might not have been if the patient had been awake. If it had been necessary to use a gas mask or an ether mask the operative field would have been impinged on and contaminated.

Another elderly patient could not tolerate block dissection of the submental and submaxillary glands of the neck under local anesthesia. Intravenous anesthetic agents were not available at the time. The use of an intratracheal tube made the operation tolerable for the patient and interfered in no way with the surgical procedure.

**Placid and Adequate Respiration**—Respiration that is labored is unsatisfactory from the standpoint of both anesthetist and surgeon. During abdominal operations movement of viscera, abdominal wall, and diaphragm which may interfere with the accomplishment of operative procedures easily can cause an operative accident because the operative target is in motion. A labored or a straining type of respiration usually increases bleeding from open vessels. Although this may be desirable and of practical importance in determining the dryness of the wound

immediately before it is closed, if an unnecessary amount of bleeding occurs throughout the whole period of operation, loss of blood is unnecessarily great and may seriously complicate the case.

Labored respiration may occur as a result of dyspnea owing to respiratory obstruction or to lack of oxygen and an accumulation of carbon dioxide. Deep respiration may be caused by pain if the patient is not sufficiently anesthetized. It may be brought about also by posture which causes respiratory embarrassment or by posture plus obesity or some physical handicap which limits the vital capacity or motion of respiratory muscles. If the patient's respirations can be made placid without the use of an overdose of anesthetic agent, the appearance of cyanosis, evidence of oxygen want or the excessive accumulation of carbon dioxide, then conditions become relatively satisfactory to the surgeon and anesthetist. This condition of placid respiration with adequate ventilation is usually accomplished by the use of an intratracheal tube. This is particularly true of those patients who have short, fat necks and thick tongues and of whom it usually can be predicted beforehand that they should be anesthetized through an intratracheal tube.

**Aid to Artificial Respiration.**—In some instances the patient is greatly benefited by artificial respiration accomplished by manual compression of the bag, administering oxygen when respiration is unsatisfactory, especially if there is evidence of marked shock. Even in some cases of radical operation on the sinuses or even removal of an orbital tumor, respiration may be affected and an intratracheal tube should be used so that artificial respiration can be performed immediately if it becomes necessary. If severe convulsions occur in the course of general anesthesia and a barbiturate is not available for their control, artificial respiration can be carried on through the intratracheal tube until some means can be found to control them.

**Stimulation of Respiration.**—The intratracheal tube lying as a foreign body in the trachea in many cases seems to act as a respiratory stimulant. It has seemed so to me in cases in which the effect from preliminary medicaments, especially morphine, is unusually marked. In these cases respiration is usually quiet during induction and inadequate when the stage of surgical anesthesia is reached. I recall the case of a patient who was addicted to morphine and who because he was in great pain received 3 grains (0.2 gm.) of morphine in the two hours preceding operation. Respiration ceased shortly and the administration of nitrous oxide and oxygen was started. After the intratracheal tube was inserted the patient's respiration immediately became satisfactory and continued so throughout a long operation. I have observed a similar effect in cases in which the ordinary doses of preliminary medication were used but in which breathing was not good during the surgical stage of anesthesia.

## ADVANTAGES OF INTRATRACHEAL TUBE FOR VARIOUS TYPES OF OPERATIONS

The intratracheal tube has a special advantage for operations on the brain. During these operations it may be difficult for the anesthetist to reach the patient's face, respirations must be unlabored and the anesthetist must be prepared to do artificial respiration at least in case of a tumor of the cerebellum for the respiratory mechanism may cease to function because of the lesion in the brain. I prefer to use an intratracheal tube for patients undergoing cerebellar operation.

It is also valuable for patients who are to have intrathoracic operations for which the means must be at hand to control intrathoracic pressure. In the course of certain operative procedures for mediastinal tumors and in most intrathoracic operations it is necessary to expand a lung that has been collapsed to make room for operative procedures. The lung often can be expanded satisfactorily without the use of an intratracheal tube but it can be done much more satisfactorily with an intratracheal tube. A most unusual type of operation in which artificial respiration may be necessary is resection of the bronchial plexus and in such a case I have found the intratracheal tube most convenient.

The intratracheal tube also is valuable for operations on the face and neck so that the patient may be properly ventilated and the anesthetist may be out of the way of the surgeon. It is important in operations on the thyroid gland when the trachea is compressed before operation. It is important in many operations in which general anesthesia is used and the patient has bilateral paralysis of the vocal cords before the operation. It is important in operations on the stomach since pyloric obstruction may result in regurgitation of gastric contents into the throat with aspiration into the trachea. This regurgitation can be minimized or eliminated by use of a well fitting intratracheal tube. In any operation in which the occasion may arise to aspirate material from the lung, an intratracheal tube makes it easy for the anesthetist to use a suction catheter through the intratracheal tube. For the patient who is to have an operation on his back the position is one that makes it difficult for the anesthetist to administer an inhalation anesthetic and so the use of an intratracheal tube usually is indicated for such operations. For operations for lesions of the large bowel an intratracheal tube makes it possible for the anesthetist to maintain a smooth anesthesia and to produce quiet respiration. Both are highly desirable in handling lesions of the large bowel as straining on the part of the patient may contribute to postoperative peritonitis in these cases.

For operations that may be associated with a considerable loss of blood in a certain percentage of cases, such as splenectomy, craniotomy or radical amputation of the breast, the use of an intratracheal tube and the placid respiration which results from its use often will permit completion of the operation without the need for transfusion. There are operations such as resection of the sensory root of the trigeminal nerve in which any bleeding into the wound interferes with the opera-

tion Use of an intratracheal tube reduces the amount of bleeding in these cases when the operation is performed with the aid of inhalation anesthesia

The intratracheal tube has been used to advantage in certain unusual situations For example, it was used to advantage for a patient who suffered from hypertension and had evidence of some cardiac disease and who was to undergo a cerebellar operation in the sitting position The use of an intratracheal tube in providing placid respiration that is adequate is usually not associated with further elevation of blood pressure and adds the least possible burden on the heart in connection with the administration of an anesthetic agent by inhalation and at the same time permits the necessary adequate ventilation

From time to time the anesthetist may be faced with a situation that has not been recognized preoperatively, namely, fixation of the vocal cords In such cases respiration will be inadequate to ventilate the lungs properly until an intratracheal tube is introduced In a very rare instance the epiglottis will fall over the glottis with each inspiration and will be blown away with each exhalation Under these circumstances the patient's condition soon becomes grave but it can be corrected by the use of an intratracheal tube

A patient who suffers from angina pectoris may require operation If the attacks are frequent and severe and inhalation anesthesia is to be used I have felt safer with an intratracheal tube in place than without it This is especially true when the anginal attacks occur during the operation and it is necessary from time to time to administer sufficient oxygen to keep the color satisfactory

Although most patients respond relatively satisfactorily to the use of an intratracheal tube, from the standpoint of correcting difficulties of respiration, there are some who in spite of the tube do not do well, for example in an occasional case the bleeding may be so severe that operation on the cerebellum cannot be continued In operations such as sympathectomy, when the patient is supported on a kidney rest, cyanosis may develop because of inadequate ventilation in spite of the use of an intratracheal tube The inadequate ventilation may be due in part to hypertension, cardiac disease or posture but probably it is a combination of several factors

#### CONTRAINDICATIONS TO USE OF INTRATRACHEAL TUBE

In some cases of acute infection of the upper part of the respiratory tract use of an intratracheal tube is probably not advisable If the tube is not used for operation on the upper part of the abdomen there probably will be less tracheitis postoperatively than when it is used There is a type of patient who cannot tolerate any trauma to the mucous membranes In one such case I observed tracheitis after the use of an intratracheal tube and urethritis after catheterization in the postoperative period

When patients have foul lesions in the mouth or on the face and have difficulty in coughing and expectorating to rid themselves of material from the respiratory passages, the use of an intratracheal tube is likely either to increase the incidence of postoperative pneumonia or if pneumonia would have developed anyway, to increase its severity. This is especially true in cases in which block dissection of glands of the neck and removal of submental and submaxillary glands are performed. I have been persuaded by some of my surgical associates that this is true, but others feel that the use of the tube is seldom associated with an increase in postoperative pulmonary complications.

### THE TUBES

The various types of intratracheal tubes are illustrated in figure 366 those which I use are illustrated in figures 367 and 368. Tubing for intratracheal use never had been designated by numbers. Therefore I selected tubes of ten different sizes and numbered them 1 to 10, the largest size being number 10. For actual use, I selected numbers 4, 5, 6 and 7. The number 7 tube is 13 mm in diameter and 260 mm long, number 6 is 12 mm in diameter and 240 mm long, number 5 is 10 mm in diameter and 200 mm long, and number 4 is 8 mm in diameter and 170 mm long. In the same way, I numbered the blades for the laryngoscope (fig 369), each blade was given a number which corresponded to the number of the tube, that is, 4, 5, 6 and 7. The number 7 blade is 145 mm long and 18 mm in diameter (inside), the number 6 blade is 140 mm long and 16 mm in diameter, number 5 blade is 135 mm long and 14 mm in diameter, and number 4 blade is 90 mm long and 13 mm in diameter. As time went on, tubes of smaller sizes were added until at present tubes that are listed as numbers 3, 2 and 1 are available commercially. Until recently these were made by the anesthesiologist from small pieces of available rubber tubing. The lumen of a tube of number 3, 2 or 1 is probably too small for easy breathing even for an infant as the wall of the tube takes up a certain amount of the space available in the infantile trachea.

The intratracheal tubes tend to increase in length and diameter because they are boiled and greased from time to time. In order to have a convenient means of recording on the anesthesia record the size of the tube used, a scale was made which is read in millimeters (fig 370). Perforations of various diameters make it possible to measure the diameter of a tube and the edge of the scale was marked off in millimeters so that the length of the tube could be measured.

**The Bevel**—The bevel on the end of the intratracheal tube should not be long. If it is, the bevel of the tube tends to attach itself to the wall of the trachea when the patient's head is turned. In an occasional case I have found it necessary because of the length of the bevel of the tube to cut a hole in the tip of the tube on the side opposite the bevel. Some anesthesiologists have suggested use of a tube beveled on the right

side through the right nostril and one beveled on the left side through the left nostril. I have been satisfied with tubes beveled only on the left side, that is, the bevel of the tube as it lies in the patient's body faces the left side of the trachea.

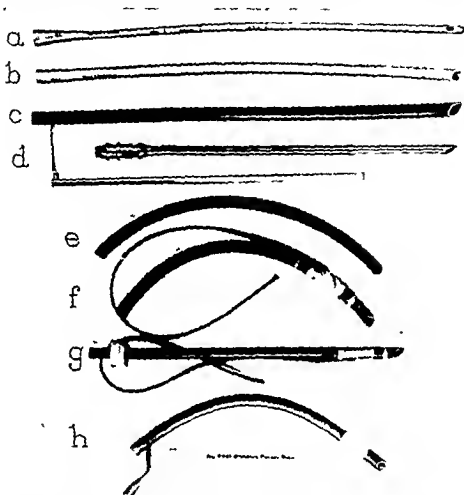


Fig 366.—Intratracheal tubes and catheters *a*, firm Magill catheter with hole on side, *b*, firm Magill catheter with hole at end, *c*, silk woven, large caliber intratracheal tube, *d*, Flagg intratracheal tube with sullet, *e*, Magill intratracheal tube, *f*, Magill intratracheal tube with inflatable cuff, *g*, silk-woven, intratracheal tube with inflatable cuff and rubber bite or with prop, *h*, Tovell's intratracheal tube with inflatable cuff (see also fig 372).

A suggestion was made when the English divided airway was put on the market about 1935 with regard to the type of intratracheal tube for use with it. Four openings on the end and four loops of rubber making a point for the intratracheal tube so that it somewhat resembled the end of a regulation American football were suggested. I have found, however, that the divided airway will permit me satisfactorily to insert a Magill intratracheal tube with the left-hand bevel.



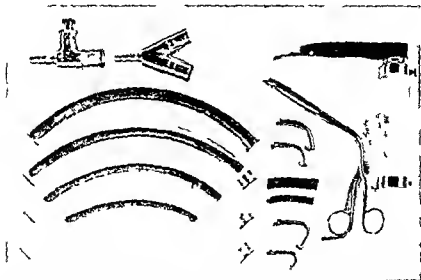


Fig 367—Magill tubes and connectors in Adams acetate plastic containers Heidbrink's adapters sterile gauze sterile white petrolatum (not evident in photograph) for lubricating intratracheal tubes Magill lighted forceps (A Mueller) Lundy laryngoscope (Welch Allen)

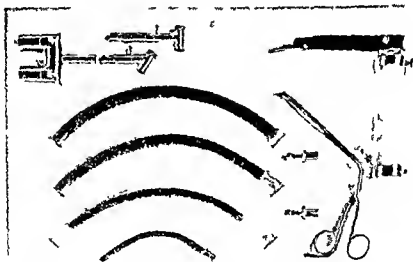


Fig 368—Magill intratracheal tubes with Adams connectors and adapters gauze with sterile white petrolatum (not evident in photograph) Magill lighted forceps Lundy laryngoscope In the small tube at bottom metal connector is in place these two pieces remain together after having once been joined In the second from the bottom the metal connector, opposite is the short style used when tube is passed through nose In the third tube from the bottom the metal connector is in place The connector is the long style for use when tube is inserted through the mouth so that patient can bite down on the tube without injury to teeth The top tube is shown with short connector opposite unattached By wetting or greasing or by placing powder in the intratracheal tube and in the metal adapter the metal adapter can be inserted more easily into the tube than if both are dry

**Parable Cut.**—The use of an inflexible cut or the cut of a tube was proposed by Grede and Waters in 1921 (67-71). Others have modified the original type of cut; for example, Torel<sup>72</sup> has written as follows concerning it:

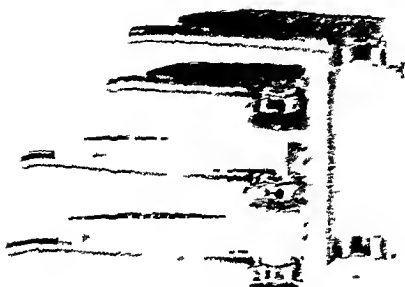


Fig. 46.—Lundy Brown & Co. Water 21" with blades or fine wires electric switch on handle for use of motor.

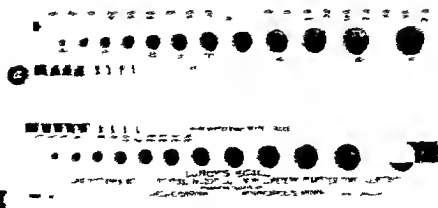


Fig. 47.—Vocal scales & one side of scale of maximum diameter and length of endotracheal tubes. A, outer side of scale for measuring depth. B, on return of how distance and local pressure needle.

In 1921 Water devised a method of administration of anesthetic agents for inhalation where a pressure control of restriction was utilized and consumption of gas was reduced. The method came to be known as the closed-circuit or rebreathing technique. In order to maintain

anesthesia efficiently it was essential that the breathing system be closed completely. To fulfill this requirement for intratracheal anesthesia, an inflatable cuff [fig. 366, f], which could be slipped on over a Magill tube was devised. Such a cuff has been satisfactory when the

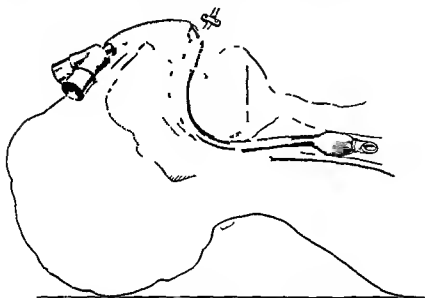


Fig. 371 Intratracheal tube with inflatable cuff

tube was introduced through the mouth but when introduced through the nose, the tube with the cuff attached was bulky. A tube with a detachable cuff has a further disadvantage in that it is difficult to clean and sterilize.

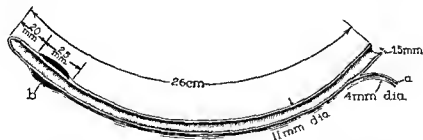


Fig. 372—Longitudinal section of Tovell's reinforced intratracheal tube with inflatable cuff

A new intratracheal tube in which an inflatable cuff has been incorporated, which is suitable for introduction through either the mouth or nose, has been devised. The tube is made of latex and the outer wall of the cuff is continuous with the outer wall of the breathing tube. The small delivery tube to the cuff has been constructed in the wall

of the larger tube. Details of construction of a tube suitable for the average adult are shown in figure [372]. This tube is sufficiently pliable and is not too bulky for introduction through the nose. It can be

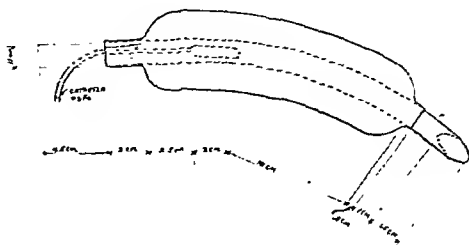


Fig. 373.—Drawing of a new type tracheal tube cuff. (From Grimm, J. E. and Knight, R. T.: An improved intratracheal technic. *Anesthesiology*. 4:6-11 [Jan.] 1943.)

washed easily with soap and water and sterilized by immersing in 0.2 per cent solution of mercuric cyanide."

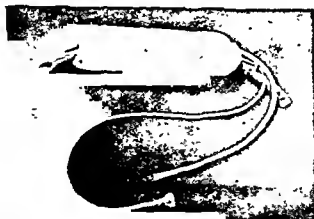


Fig. 374.—Special tube with built-in suction catheter. (From Grimm, J. E. and Knight, R. T.: An improved intratracheal technic. *Anesthesiology*. 4:6-11 [Jan.] 1943.)

At present the cuff is used on the tube in certain cases but for general use the Magill intratracheal tube as it is made in this country serves well.

Grimm and Knight<sup>4</sup> of the University of Minnesota have devised a cuff (fig 373) which they have described elsewhere. Using a condom the trachea, the larynx and part of the pharynx are filled when it is inflated. It is safe and is an improvement over the older type. A suction catheter may be installed for special cases (fig 374). The cuff is connected with a manometer or device in such a way that the anesthesiologist always knows whether the cuff is still inflated.

#### POSITION OF VOCAL CORDS

Before the technic of insertion of the intratracheal tube is considered, the position of the vocal cords in inspiration and expiration should be mentioned briefly. In ordinary inspiration the vocal cords are drawn together to guard against the inhalation of any foreign material. However, on inspiration the vocal cords may be separated under certain circumstances, as for example when the patient gasps from dyspnea or in response to some agent such as carbon dioxide which produces a systemic effect or a local effect when it strikes the glottis, or such as atropine which produces the effect when it is injected intravenously. Ordinarily on expiration or coughing the vocal cords are separated to facilitate the expulsion of any solid or fluid material that has accumulated together with the air or gases. Phonation indicates that the vocal cords are close together. Expiratory phonation indicates that the cords are together on expiration. Inspiratory phonation indicates that the cords are together on inspiration. The tube *should be passed during the phase of respiration when phonation is absent*.

#### INSERTION OF INTRATRACHEAL TUBE AND RELATED MEASURES

**Preliminary Medication**—Preliminary medication should be used in cases in which an intratracheal tube is to be used. Such medication consists of  $1\frac{1}{2}$  to 3 grains (0.1 to 0.2 gm) of pentobarbital sodium,  $\frac{1}{8}$  grain (0.01 gm) of morphine and  $\frac{1}{150}$  grain (0.00043 gm) of atropine for the average adult.

**Anesthesia before Passing Tube**—The technic of introducing the Magill intratracheal tube varies with the circumstances under which it is to be used. If it is to be passed through the nose by Magill's method of so-called blind intubation, the throat should be sprayed before induction of general anesthesia with a surface anesthetic solution. Although Magill uses a 20 per cent solution of cocaine, I have used a 5 per cent solution of butyn or metycaine. The solution can be sprayed along the floor of the nose with the patient inhaling until he admits a definite change of sensation in the larynx. Usually general anesthesia is induced either intravenously or by inhalation before insertion of the tube, but the rectal method may be used. The anesthetic agents usually administered by inhalation are nitrous oxide, oxygen and ether, ethylene oxygen and ether, nitrous oxide, oxygen

and cyclopropane, or cyclopropane and oxygen. If ether is to be avoided, the best mixture for preliminary anesthesia is cyclopropane and oxygen. Relaxation will last long enough after the mask is removed so that the laryngoscope can be used. If the stage of anesthesia which will permit passage of the tube is difficult to determine, a relatively high concentration of ether can be given for one or two breaths to see whether the patient will cough. If he does not cough, he probably is ready for insertion of the tube.

*Weak Anesthetic Agent Employed*—When an intratracheal tube is to be introduced into the trachea of a patient who is anesthetized with a weak anesthetic agent, such as nitrous oxide and oxygen or pentothal sodium, two aids should be used: (1) the throat and larynx should be sprayed with a 20 per cent solution of cocaine or 5 per cent solution

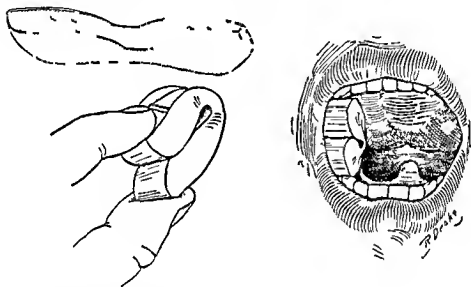


Fig. 375—A DePass mouth prop (Automatic Rubber Company, Columbia S. C.). Upper left, extended; lower left, bent; right, it is inserted between the teeth of the upper and lower jaws of the left side of the mouth.

of metycaine or butyn and (2) a mouth prop (DePass) should be used to separate the teeth on the left side before anesthesia is induced (fig. 375). When nitrous oxide and oxygen only are used, the anesthesia is carried to a point at which cyanosis has definitely developed before intubation is undertaken. Everything that is to be used must be readily at hand. The lighted laryngoscope is introduced through the open mouth and over the tongue as soon as possible after the mask has been removed from the patient's face so that the intratracheal tube can be introduced within the first two or three breaths. If the throat reflexes become active, it will be necessary once more to induce general anesthesia with nitrous oxide and oxygen. In some resistant cases it is desirable, and it may even be necessary, to induce anesthesia with cyclopropane and oxygen, for in this type of anesthesia the throat

reflexes are abolished long enough so that the tube can be introduced in an unhurried fashion. In either event once the tube has been introduced anesthesia can be maintained in most cases with a mixture of 85 per cent nitrous oxide and 15 per cent oxygen or perhaps 90 per cent nitrous oxide and 10 per cent oxygen for certain periods of the operation.

Since anesthetic agents for intravenous anesthesia have rapidly become generally available intratracheal tubes probably will be introduced under intravenous anesthesia more and more commonly. As mentioned previously it is of course important when intravenous anesthesia is employed that the patient's throat be sprayed with a local anesthetic agent to reduce activity of the throat reflexes. A mouth prop also should be used. As the needle is inserted into the vein by an assistant the anesthetist picks up a lighted laryngoscope and inserts it about  $1\frac{3}{4}$  inches (3.7 cm) past the teeth and then the intravenous administration of the anesthetic agent is begun. Respirations are observed and when they become quiet insertion of the tube is carried out.

**Position of Patient.**—In order to insert the tube easily the patient should be supine and in the face up position. His head should be in the same relation to his body when he is lying down as that of a soldier who is standing at attention. It is advantageous to have the crown of the patient's head an inch (2.5 cm) or so beyond the head of the table and against the anesthetist's abdomen.

**Selection, Preparation and Inspection of Tube.**—The tube to be used through the nose should be longer than the tube to be inserted through the mouth. A tube that is a little short is safer than one that is too long for it is safer to have the tube come out of the trachea and larynx and lie in the throat than for it to become kinked and still remain in the trachea.

While the tube is being greased with white petrolatum on a sterile sponge it should be straightened out and the inside inspected as the inside of the gun barrel would be inspected to see that there is no foreign material in the tube.

**Nasal Intubation (Blind Intubation).**—*For Well anesthetized Patient.*—The tube is introduced along the floor of the nose after the tube has been lubricated (fig. 376) as soon as possible after the mask has been removed from the patient's face. After the mask is removed the patient's jaw is either depressed a bit or at least not raised. This position of the jaw prevents good respiratory exchange for a few breaths and helps keep the patient from rousing quickly from the anesthesia. In many cases it is possible to have the tube in place by the time the patient has taken only six or seven breaths after the mask has been removed. If the patient takes as many as fifteen or twenty breaths after the mask is removed the throat reflex may become active and intubation may become difficult.

The tube should not be pointed toward the roof of the nose but along the floor of the nose. If it does not pass through one nostril easily, the tube should be withdrawn and passage through the other nostril tried. If there still is resistance, a smaller tube should be selected. The right-handed anesthetist tries the right nostril first and the left second. It seems to make little difference in the average case which nostril is used. Occasionally there is some difficulty in getting the tube to make the turn downward through the nasopharynx after the floor of the nose has been traversed. It is unwise to traumatize the



Fig. 376.—Nasal intubation without the laryngoscope. Intratracheal tube is inserted along the floor of the right nostril.

posterior surface of the nasopharynx with the tube and too much pressure at this point may cause bleeding or cessation of respiration. Cessation of respiration also may occur if the nasopharynx is packed too tightly, for when the pack is loosened, breathing is resumed. However, if the bevel of the tube is utilized, that is, by rotating the tube to bring the bevel against the posterior wall of the nasopharynx, it then can be passed into the oropharynx with relatively little trauma (figs. 377 and 378, A, B and C).

The tube is advanced then and in at least half of the instances when the patient has been well anesthetized, it will continue to its full length



without change in the tubular breathing. When phonation on the part of the patient ceases the anesthetist is aware that the tube has separated the vocal cords. Since this type of intubation is a blind procedure and the anesthetist is usually unaware through his sense of touch of the progress of the tip of the tube from one part of the upper respiratory tract into the next (fig. 378, D), the anesthetist's ear should be fairly close to the external end of the tube where the hollow tubular breathing of the patient will be audible. If the tube can be introduced its full length (260 mm or 26 cm for the average adult) and breathing is



Fig. 377 Nasal intubation without the laryngoscope. The tube is inserted through the nasopharynx and oropharynx until the tip is in front of the glottis. The patient is breathing through the tube because the anesthetist closes the lips and the left nostril. The head is in the face front position. The anesthetist rotates the external end of the tube in an attempt to bring the beveled end of the tube in front of the larynx.

still of the tubular variety, it is in the trachea unless the tube is soft and old and has curled up in the throat. To make certain that the patient is breathing through the tube the patient's lips should be covered for a moment with the fingers of the anesthetist's left hand and his left thumb should press the left nostril closed when the tube is in the right nostril.

If the tube does not enter the trachea on the first or second thrust but enters the esophagus (fig. 378 B) it should be pulled out far enough so that the beveled end is outside the esophagus and breathing

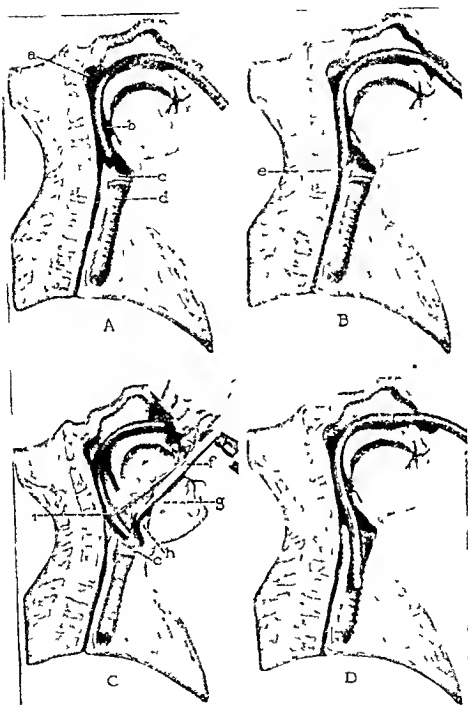


Fig 378—Nasal intubation *A*, The tube through the nose and *a*, nasopharynx and extending well into *b*, the oropharynx, *c*, vocal cords, *d*, trachea *B*, Tip of tube enters *e*, esophagus *C*, Laryngoscope, *f*, inserted through opened mouth, exposes *c*, glottis and vocal cords, by moving *g*, the tongue, and *h*, epiglottis, out of the line of vision, *i*, Magill forceps grasps the tube near the tip and directs it into the glottis *D*, Nasal tube properly placed, the tip lying midway between the glottis and the bifurcation of the trachea

through the tube is resumed. It is important that the inexperienced anesthetist releases the tube at this time and to see in which direction the external end points. Since the intratracheal tube is curved almost semicircularly, the external end, when not held in the hand, will point in the same direction as the beveled end. It is advisable to turn the patient's head to the right and to try to introduce the tube into the trachea and, if this maneuver is unsuccessful, the head should be turned well to the left and introduction then should be tried again (fig 379). The reason for turning the head is that if the tube cannot be brought in front of the larynx easily, then it may be possible to bring the larynx in front of the tube. If the head is not turned to the side the



Fig 379 If the tube cannot be inserted easily with the head in the face front position the head can be turned to one side or the other in the hope that the larynx can be brought in front of the tube so that it will enter the larynx.

tube should be rotated in order to bring the bevel into the mid-line. The anesthetist should be able to do this by observing the direction in which the external part of the tube points. In some cases it will be necessary to raise the patient's head by using a hard pillow. The anesthetist can raise the patient's head which is pressed against his abdomen by standing on his tiptoes and holding his left hand against the patient's chin.

*For Partially Anesthetized Patient*—If a patient is not anesthetized easily, difficulties often will be encountered which cannot be controlled without the use of an intratracheal tube. It may be desirable, therefore, to reverse the ordinary procedure in which the patient is first put to sleep and then the tube is inserted. It may be necessary to

insert the tube before the patient can be brought to the desired stage of anesthesia. The situation has arisen often enough in my experience so that it was necessary to develop a technic for introducing an intratracheal tube under such circumstances. My method is to stand in the same relation to the patient as is shown in figure 376 but instead of raising the jaw with the left hand, the jaw is depressed with the left hand so that respiration is obstructed. This is continued for four or five breaths and meanwhile the intratracheal tube is inserted through the nose (fig. 376). As soon as the tube has reached a point just over the larynx, as in figure 378, *A*, then the maneuver as in figure 377 is

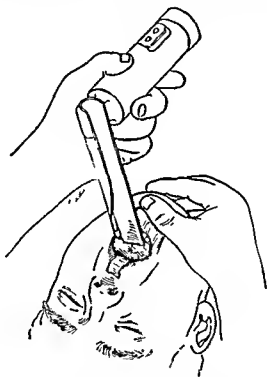


Fig. 380.—Insertion of laryngoscope, step 1. head extended, mouth opened, adhesive tape on teeth and upper lip, lower lip rolled away from the teeth, tip of laryngoscope introduced to the middle of the tongue

carried out, and, in addition, the jaw is elevated and the tube is simultaneously inserted. Actually, as the patient gasps for air, he aspirates the tube, for as soon as the respiratory obstruction is relieved the lightly anesthetized patient tends to inhale deeply and will usually inhale the tube. Although this technic is not always successful, it frequently is and the benefits derived from it are real.

**Insertion of Laryngoscope.**—When an attempt to place the tube blindly has not been successful in about a minute, use of the laryngoscope should be resorted to at once. This instrument, for the right-handed anesthetist, should be held in the left hand. The handle should be at right angles to the blade and the instrument should be of the

battery type. The anesthetist should remove the pillow from under the patient's head and tilt the chin upward with his right hand. A strip of adhesive plaster 1 by 2 inches (2.5 by 5 cm) should be applied to the upper central incisor teeth and the upper lip. The adhesive plaster protects the teeth against roughening by the metal blade of the laryngoscope to some extent. The anesthetist rolls back the patient's lower lip with his right thumb. The tip of the blade of the laryngoscope is inserted over the lower teeth without pinching the tongue (fig. 380). If the patient's head is not tilted sufficiently, an assistant may tilt it. The anesthetist must see to it that the patient's tongue is forced over into the left side of the patient's mouth or into the left cheek. In this way the tongue will lie behind the laryngoscope so that it does not

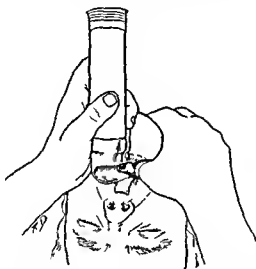


Fig. 381. Insertion of laryngoscope, step 2. laryngoscope inserted with left hand, lower jaw pulled up onto the laryngoscope with the right hand, uvula in sight.

interfere with the anesthetist's vision. No strong effort should be made with the left hand in the introduction of the laryngoscope. The instrument is simply held firmly enough so that its direction can be maintained and so that it will stay fairly well in the mid line of the mouth or to the right of the mid line. Maintaining the position may be difficult in an edentulous mouth unless a large blade is used. In general, however, it is easier to insert a laryngoscope when there are no teeth than when there are teeth.

When a fifth of the blade has been introduced, the anesthetist should see to it that the tip of the laryngoscope is not striking the hard palate. This injury must be avoided and can be by the anesthetist's introducing his right thumb so that it rests on the top of the back teeth in the right side of the lower jaw. The fingers of the anesthetist's

right hand then should grasp the right lower border of the mandible. The jaw then is pulled up onto the laryngoscope and at the same time the anesthetist's left hand forces the laryngoscope into the pharynx (fig. 381). This motion is similar to that of a man drawing on a riding boot; that is, he partly pulls the boot on and partly shoves his foot into it.

When a half to two thirds of the blade of the laryngoscope is inserted, the base of the tongue can be seen and next the epiglottis is visualized (fig. 382, *a*). At this point the anesthetist must reach a bit further and direct the laryngoscope toward but not against the pos-

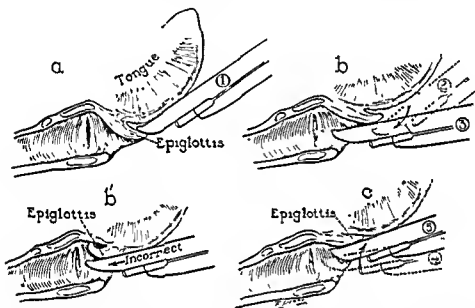


Fig. 382.—Insertion of laryngoscope *a*, epiglottis visualized; *b*, the tip of the laryngoscope is depressed with the left hand while the jaw, tongue and epiglottis are supported by traction from the right hand, *b'*, incorrect method in which the laryngoscope is advanced from *a* without depressing the blade as in *b*; *c*, the epiglottis is picked up by the laryngoscope which then supports it, the tongue and the jaw so that the right hand is released.

terior wall of the oropharynx (fig. 382, *b* and *b'*), and then bring it forward so that the tip of the laryngoscope will press the epiglottis against the base of the tongue and leave the vocal cords exposed to view (fig. 382, *c*). In the introduction of the laryngoscope into the mouth, it is important that the anesthetist does not look through the laryngoscope all of the time; he should also look at the lips, teeth, tongue, palate and so forth at intervals.

When the vocal cords are brought into view, the anesthetist holds the laryngoscope firmly with the left hand but does not pry against the upper central incisor teeth. Rather, he lifts the laryngoscope upward without bearing much weight on the patient's upper teeth.

**Nasal Intubation with Aid of Laryngoscope.**—When the glottis is exposed by the laryngoscope, the tube through the nose can be manipulated and inserted into the trachea with little difficulty. If difficulty is encountered in this procedure, the tip of the tube can be directed into the glottis with the aid of a Magill forceps (fig. 378, C). The usual reason for using a forceps is that the tube is so soft that the beveled end cannot be directed by manipulating the other end of the tube. Another reason is that when the patient is thin, the anterior surface of the cervical vertebrae seems to push the posterior mid line of the throat forward and the sides of the throat seem to recede so that there is a gutter on each side. If the tube is inserted by way of the nose and there is exostosis of the cervical vertebrae, it may not be possible to insert the tube down the mid-line. When little of the glottis can be exposed to view by using the laryngoscope, it may be necessary to direct the beveled end of the intratracheal tube with forceps in order to insert it at an angle to the blade of the laryngoscope. This might be called "blind intubation" through the mouth with the aid of the laryngoscope. However, if the patient's head has been extended too far, the tube may come to rest across the rima of the glottis at such an angle with its long axis that it will not enter until the patient's head is brought fairly well forward. This can be done by an assistant without the anesthetist's removing the laryngoscope.

**Fastening the Nasal Tube in Place.**—In order to prevent a nasal tube from falling out of the trachea and larynx, it should be securely fastened to the upper lip. This precaution is especially necessary if the tube is short enough so that the tip lies within the larynx and does not extend into the trachea far enough to allow some movement of the tube without displacement. When ether is to be given by the open mouth and the intratracheal tube, the external end of the tube

the ether mask. Unless tubes are cut to suit a particular patient, the tube may be so long that it extends beyond the bifurcation of the trachea and into the right or left bronchus. If respiration is not satisfactory—that is, if it is too slow or jerky or if the patient is slightly cyanotic when breathing air, respiration can be improved by the partial withdrawal of the tube so that the beveled end is above the bifurcation of the trachea.

**Oral Intubation—After Induction of Adequate Inhalation Anesthesia.**—The tube should be withdrawn quickly from the nose if it does not readily enter the larynx and it then should be introduced parallel to the laryngoscope through the mouth and between the vocal cords (fig. 383, A). It is desirable for the anesthetist to be able to look through the laryngoscope rather than to use the laryngoscope for a "blind" intubation. Under these conditions the tube can be dislodged



Fig 383.—Oral intubation. *A*, Laryngoscope and tube, *f*, laryngoscope moves *g*, tongue, and *b*, epiglottis, so that *c*, the vocal cords, are exposed to view, the intratracheal tube is inserted along the blade into the glottis and trachea. *B*, Same as *A* except that *i*, Magill forceps, directs the tip of the tube into the glottis. *C*, The full length intratracheal tube lying in place so that its tip almost reaches the bifurcation of the trachea. It is in this position that the tube must lie when the trachea has been compressed by an intrathoracic tumor (goiter). Note the difference in the placement of the tubes here as compared with that shown in figure 378, *D*



from the blade of the laryngoscope and the Magill forceps used to hold the tube. Only rarely can the anesthetist hold the tube straight enough to look through it, while it is being introduced. Occasionally, a Magill forceps may be necessary in order to introduce the tube through the mouth with the aid of a laryngoscope (fig 383, B).

In a rare case the anesthetist may blow his breath against the patient's vocal cords through the tube and the cords will sometimes separate for a moment and let the tube enter the larynx. In an emergency when a patient stops breathing and the tube is in place in the trachea, the anesthetist can often obtain good results by mouth to tube insufflation. When the tip of the intratracheal tube has just passed the rima of the glottis the anesthetist should glance away from the tip of the tube and note how much of the outer end of the tube protrudes beyond the teeth. In an adult about 2 or 3 inches (5 or 7.5 cm) of the tube should be inserted beyond the vocal cords. After the tube has been set in place the laryngoscope is withdrawn (fig 383, C).

*After Induction of Intravenous Anesthesia*—When respirations have become quiet the laryngoscope is gently introduced over the tongue, care is taken to avoid stimulation of the throat reflexes any more than is necessary, the epiglottis is elevated gently and the intratracheal tube is poised so that its beveled point is immediately in front of the rima of the glottis. When the vocal cords are separated, the tube is quickly pushed between them. In this technic it is important that the vocal cords are not touched by the tube until the definite motion to insert the tube is made. If the throat and vocal cords are touched two or three times by the tube in an attempt to introduce the tube, the throat reflexes will usually become active. The vocal cords will come together tightly and if further efforts are made, the glottis may contract almost like a sphincter and even the cords will be covered up. Occasionally, if the local anesthetic agent has been fairly effective and fairly deep anesthesia has been produced by the anesthetic agent given intravenously, the vocal cords will be brought together, but if they are, they will not be held firmly together. This occurs especially in cases in which preliminary medication has been given. In such cases it is sometimes possible to place the point of the tube against the cords so that the tube will pass between them. This technic is not recommended for general use as it may traumatize the vocal cords, but if conditions warrant such a risk it may be tried as it often works.

At present it is not uncommon to give both pentothal sodium by the intravenous route and nitrous oxide and oxygen by inhalation to facilitate the introduction of an intratracheal tube. It seems clear that once the intratracheal tube has been placed, then nitrous oxide and oxygen by inhalation and pentothal sodium given intravenously can be used readily and easily and without danger of fire or explosion and such a method has value when cautery, diathermy, and electric devices are so frequently used.

**Support for Oral Tube.**—Some support should be given to the oral tube, such as that provided by a metal connector, to prevent the patient from flattening the tube by biting on it. A cyanotic patient tends to have muscle spasm and if this involves the muscles of mastication, the patient increases the cyanosis and spasms by biting on the tube through which he must breathe in order to relieve the cyanosis. If a tooth is missing, that space can be utilized for the tube.

**Removal of Tube from Nose and Insertion through Mouth during Operation.**—If a nasal tube becomes kinked during the operation because of the position of the patient's head, it may be necessary to remove the tube and introduce it through the mouth in the midst of the operation without changing the position of the patient. The difficulties of this procedure may be great. If a laryngoscope cannot be used and if the anesthetist's fingers are long enough to reach well into the throat, the tube can be introduced by touch through the mouth. The English divided airway (fig. 384, *a* and *b*) is valuable under such difficult circumstances as the tube can be greased and introduced into the airway (fig. 384, *c*) and both can be inserted between the teeth and over the tongue until tubular breathing is maximal. The tube is then advanced through the divided airway and in most instances will enter the trachea. If the anesthetist must work at arm's length and cannot bring his ear to the tube to ascertain whether the tube is in the trachea or whether it is in the esophagus then a piece of paper or a finger cot can be held over the end of the tube and breathing through the tube can be noted. In a rare case it may be necessary to leave the airway in place as a splint to the intratracheal tube to prevent it from kinking.

**Insertion of Tube in Esophagus.**—If the tube cannot be inserted into the trachea but it can be inserted into the esophagus, an airway may thus be provided that is better than no artificial airway for the patient may be able to breathe along the outside of the tube. I have used this procedure only once and then only until anesthesia became deep.

**Procedure when Laryngoscope Cannot Be Used to Check Position of Tube during Operation.**—If the patient is to be placed in a position in which it will be difficult for the anesthetist to use a laryngoscope to check the position of the tube after operation starts, it is advantageous to do so before the patient is taken from the cart or table on which he is being anesthetized and before he is placed in position for the operation.

**Pressure in Bag.**—In most cases in which a mild anesthetic agent is used the introduction of a relatively small tube is easier than the introduction of a larger size tube. If a tube does not fit snugly enough to exclude air on inspiration when the pressure in the breathing bag is low (2 mm of mercury), then a larger flow of gas and more pressure (5 to 6 mm) in the bag will overcome this difficulty. However, the pressure in the bag at the height of expiration should not be greater than 12 mm of mercury. A reasonably ample flow of gases should be

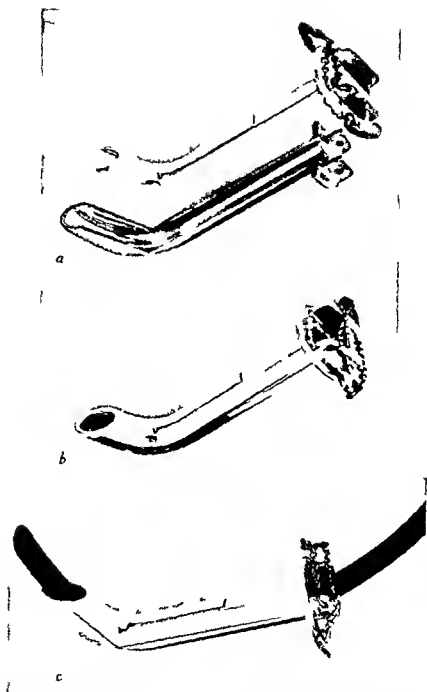


Fig 384—English divided airway *a* separated into its two parts *b* assembled *c* serving as guide for lubricated intratracheal tube (Divided Airway Co., London)

used and the expiratory valve should be adjusted in order to limit the pressure. This technic is employed usually for short operations when ether and other anesthetic agents except nitrous oxide and oxygen are to be avoided.

*Immobilization of Tube*—When the tube has entered the trachea if the patient is in a light plane of anesthesia, coughing usually takes place as long as the tube moves within the trachea. It is important to immobilize the tube if coughing is to be minimized. This is usually accomplished by using a strip of adhesive plaster to fasten the tube to the upper lip and cheeks, a safety pin also can be used with the adhesive plaster. If an adapter is used, it helps to hold the tube still.

*Nasal Versus Oral Intubation*—Although the nasal route for the introduction of an intratracheal tube is invaluable, for the most part I prefer to insert the tube through the mouth. The tube introduced through the mouth is less likely than the nasal tube to be inserted too far into the trachea and during or at the end of operation it is much easier to insert a soft, urethral type of suction catheter through the intratracheal tube that is through the mouth than through the nose.

*Aspiration with Intratracheal Tube in Place*—If an intratracheal tube has been placed by way of the nose a small, semistiff silk woven catheter which must be well greased before it will follow the curve of the intratracheal tube (fig. 378, A, a) often is required for aspiration. In rare instances in which the intratracheal tube must be placed by way of the nose and it is known beforehand that a suction tube must be passed through the intratracheal tube, it is desirable to grease the intratracheal tube on the inside as well as on the outside before it is used. The ordinary urethral catheter is barely long enough to reach deep lying mucus and when such a catheter is used, it must be inserted full length. If the patient is lightly anesthetized, he will tend to cough and by so doing he tends to bring mucus up to the end of the catheter.

For best results special catheters are needed, these should be 6 inches (15 cm) longer than urethral catheters and made of a stiffer material, for example, woven silk catheter (14 F) with an angular finger valve. If a special catheter is not available, then an extension tube or something else must be devised for the ordinary urethral catheter so that it can be made long enough to reach the location desired.

*Aspiration without Intratracheal Tube*—During or at the end of operation it may be necessary to carry out aspiration from the tracheobronchial tree even though the intratracheal tube has not been used. This can be accomplished by using a laryngoscope, a semistiff catheter and suction. A soft catheter cannot be directed well enough to be useful in this connection although if nothing else is at hand the anesthesiologist will be forced to use it.

## MODIFICATIONS OF TECHNIC FOR VARIOUS CONDITIONS AND FOR INFANTS AND CHILDREN

**Ankylosis of the Jaws**—If the patient has a full set of teeth and the teeth cannot be separated because of ankylosis of the jaws the only way in which the tube can be introduced is by blind intubation through the nose. In these cases it is most important to use preliminary medication and to spray the throat thoroughly with a solution of a local anesthetic agent by way of the nose. Usually nitrous oxide oxygen and ether are administered by inhalation or even drop ether may be used. The aim is to have the patient well anesthetized so that the throat reflexes will not interfere with the introduction of the tube. These patients should be carried into about the middle of the second plane of the third stage of surgical anesthesia before the tube is inserted.

A tube that is not too large to enter the nose easily should be selected. If no time is lost, it almost always can be introduced into the trachea without trouble. However, if difficulty develops, it is possible partially to withdraw the tube until the tip of the tube is above the larynx. Then the tube is connected to the gas machine and nitrous oxide and oxygen are administered intrapharyngeally. As soon as anesthesia has been induced again, the tube is moved forward and backward slowly and sometimes it will enter the glottis and trachea. This technic also may be tried for dental operations if other means of introducing the tube under

This same technic, of ankylosis of the jaws

way. For such patients as well as for patients whose jaws can be separated but a short distance even though no ankylosis is present, the Seldon blade (fig. 385), which is even flatter than the collapsed blade of the Mosher laryngoscope, can be used. Laryngoscopes with relatively small, rounded blades (Kaye, Eversole) permit visualization of the glottis when it is difficult to separate the teeth. If the separation of teeth is still less, a flat blade can be inserted from the corner of the mouth rather than from the region of the upper central incisors and the glottis can be viewed from an angle. The relation of the tip of the tube to the glottis, however, can be visualized and by this means introduction of the tube is made possible.

When the teeth can be fairly well separated but still not enough so that a regular laryngoscope blade can be introduced over the central incisors and the glottis brought into view, the full size blade of the laryngoscope can be introduced from the side of the mouth and the glottis can be visualized. Introduction of the laryngoscope from this angle is also valuable for the patient who has prominent upper central incisors. In some cases the tube can be inserted through the lumen of the blade. In some cases, if several adjacent teeth are missing, the blade of the laryngoscope if a small one is used, can be placed in the

space between the teeth and the tube can be inserted through the lumen of the blade

When it is impossible to insert even a flat blade and the tongue can not be pulled forward with Ochsner-Allis forceps, the tongue can be rolled up on the forceps and pulled forward to make room for the tube to come forward far enough to enter the larynx

**Absence of Teeth**—From the one extreme of complete ankylosis the other extreme must be considered, namely, the patient without teeth who is well relaxed. For these patients a laryngoscope with a small blade tends to slip on the gums and get into a position in which the glottis cannot be visualized satisfactorily. It tends to slide off into one corner of the mouth so that it is not easy to introduce the tube through the glottis and into the trachea. Under these circumstances the tube



Fig 385—Seldon's blade for Lundy laryngoscope (Welch Allyn). Blade is flat and can be inserted between teeth that can be separated but little

tends to cross the lumen of the glottis at an angle and not enter it. In this situation the divided airway can be used instead of the laryngoscope or the anesthetist's left forearm can be pressed against the left side of the patient's head in order to immobilize the laryngoscope and prevent it from slipping in the mouth.

**Through Tracheotomy Opening**—Whenever a patient who has a tracheotomy opening must be anesthetized, an intratracheal tube large enough to fill the opening is selected. For the average adult the tube is about 4 inches (10 cm) long. It is attached to a curved metal Magill nasal adapter with a short rubber tube connection (fig 386). This intratracheal tube is greased and is inserted through the tracheotomy opening into the trachea before anesthesia is induced. This usually causes a mild attack of coughing, but if the patient has been warned of what is to take place, it will cause little difficulty. As soon as the

tube is in place, it is immediately connected by means of a connection to a gas machine and nitrous oxide and oxygen are administered. Coughing will cease in a few minutes and anesthesia will develop. Pentothal sodium given intravenously can be used to make the introduction of the tube easy and to keep the patient quiet while anesthesia is being induced by the inhalation method.

**For Application of a Head Neck and Body Cast**—With the intratracheal tube in place a second tube can be attached to the external end of the first tube and by means of adapter and inhaler tubing it is connected to the gas machine. A sufficient flow of gases is used so that the machine supplies the patient with a mixture which is under just enough pressure so that labored respiration does not occur. An intratracheal tube connected in this manner permits the anesthetist to get back out of the surgeon's way and expedites the application of the cast.

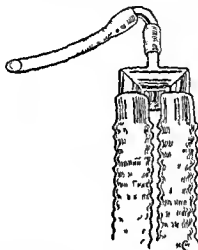


Fig. 386 Shortened Magill intratracheal tube for insertion through a tracheostomy opening. It is shown connected to the inhaler tubes.

**For Children and Infants**—The embryologic development of the child must be taken into consideration whenever intratracheal anesthesia is contemplated for a child ten years of age or less. Since the head is larger in proportion to the neck and the neck is larger in proportion to the chest, a tube that can be introduced through the nose may not enter the larynx and one that can be introduced into the larynx may not enter the trachea at all. It thus may be possible to introduce the tube through the nose of a child, but if it does not enter the trachea after one or two attempts the laryngoscope should be used and the tube inserted under direct vision through the mouth. If, after one attempt, it does not enter the trachea a smaller tube should be used so that the glottis will not be traumatized. The tube must be small enough so that it will enter the glottis and trachea without force. A Magill tube

that fits the glottis and trachea of an infant tightly may cause edema which is undesirable and which may end fatally.

Epistaxis or bleeding from the throat of a child or infant may be easily produced by trauma from the tube. Ordinarily, it causes little difficulty but if the anesthetist has not informed the surgeon of its occurrence and blood is swallowed and later vomited, the surgeon may be in doubt as to the reason for the patient's regurgitation of blood.

An intratracheal tube is usually contraindicated for a child that is one year or less of age because a tube that can be inserted into a tiny trachea does not have a large enough lumen to provide easy respiration for an infant. Trauma from the end of the intratracheal tube to an infantile glottis may easily produce edema which will entirely obstruct respiration postoperatively; this may require tracheotomy which may be followed by pneumonia and death. When an intratracheal tube

Ayre's T piece

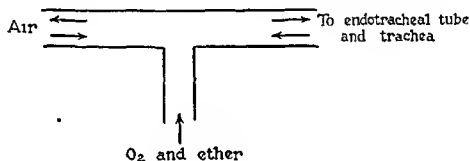


Fig 387.—Diagrammatic representation of Ayre's T piece Through the side arm of the T piece oxygen or oxygen and ether are admitted. One end of the T

piece The smaller end of the angle piece is inserted into the intratracheal tube Thus, to and fro respiration with the outside air is possible

must be used for a child or infant, it is best to use Ayre's technic as modified and described by Adams<sup>1</sup> as follows

**AYRE METHOD<sup>2, 3</sup>**—Ayre has devised a modified intratracheal method which he named the "open" technic He has employed it primarily for the operations for harelip and cleft palate on babies These operations have been performed largely under the "Junker" method or by means of closed intratracheal anesthesia with nitrous oxide, oxygen and ether Both these methods have disadvantages With the Junker method the control of the airway is often poor, the danger of aspiration of blood into the trachea is always present and an even level of anesthesia is often difficult to maintain Closed intratracheal anesthesia is exhausting to small infants, particularly if the operation is prolonged, and in addition to this, as Ayre pointed out, it causes vascular congestion, increased oozing and loss of blood from the operative site

**Technic**—Ayre sought to overcome these disadvantages by permitting open to and fro breathing with the outside air but at the same time utilizing the advantages of an intratracheal tube. The apparatus is simple and the technic un-



complicated. The equipment consists of a metal T piece [fig 387], a metal angle piece suitable lengths of rubber tubing and Magill intratracheal tubes [fig 388 a and b]. For infants up

The routine employs the open drop method

trauma has been accomplished. A suitable size of intratracheal tube (No 0 to 2) is chosen and is inserted into the trachea by the oral route with the aid of a laryngoscope. The passage of the intratracheal tube through the vocal cords can



Fig 388 Ayres intratracheal apparatus *a* component parts consisting of intratracheal tube T piece three sizes of connecting pieces and large bore rubber breathing tube *b* apparatus assembled this shows the small rubber tube connected to the side arm of the T piece through which oxygen and ether vapor are introduced

be facilitated by the insertion of a blunt stilet within the intratracheal tube to increase its rigidity. This stilet should not project beyond the open end of the tube. Usually the tube is inserted about  $\frac{1}{2}$  to  $\frac{3}{4}$  inch (0.6 to 1.2 cm) into the trachea. The stilet is then withdrawn. The end of the tube which protrudes from the mouth is then cut off level with the teeth and the small end of the metal angle piece is inserted well into it in order to prevent compression of the tube by the mouth gag or other instruments during the operation. The distal end of the angle piece is connected by about an inch (2.5 cm) of rubber tubing to one of the

large open ends of the T piece To the corresponding end of the T piece is attached a rubber tube, about 10 inches (25 cm) in length and about 11 to 13 mm in diameter The distal end of this tube is open to the air to permit to and fro breathing To the small side inlet of the T piece is attached a rubber tube which delivers oxygen with ether vapor from any suitable apparatus used for this purpose

When the apparatus is in position, the angle piece is fixed with adhesive tape to the infant's chin and the T piece lies vertically below the chin The distal length of rubber tubing lies underneath the sterile drape in such a position that the outlet is free and the anesthetist can listen to the patient's respirations A fine strip of absorbent cotton or cleansing tissue can be fixed with adhesive tape over the end of the tube, and this will move to and fro with each breath and will aid in the observance of the patient's respirations It may be necessary to adjust the amount of rebreathing by altering the length of the rubber tube to suit the tidal volume of the infant

*Uses and Advantages*—Ayre's method has proved decidedly advantageous for operations for harelip and cleft palate on infants for whom an intratracheal tube is needed because respiratory effort is minimized and anoxemia is prevented Babies for whom the method is employed usually recover rapidly at the end of the operation and show few signs of shock or untoward effects Deep anesthesia is not necessary during the course of the operation and only minimal amounts of ether (2 to 4 fluidrachms, 7 to 15 c c, per hour) are required for maintenance It may be necessary at first to bubble the oxygen through the ether but after fifteen to thirty seconds the concentration of ether vapor may be reduced to the minimum, and the oxygen may be allowed to pass over the surface of the ether only The flow of oxygen usually required will range from 15 to 3 liters per minute

This method of anesthesia has proved of advantage for intracranial operations, since the minimum of congestion and intracranial pressure is important in this type of operative procedure Larger tubes, adapters and T pieces are necessary when the method is used for adults Although the scope of Ayre's method is limited, it may well be borne in mind for operations of the nature previously mentioned

#### COMPLICATIONS ASSOCIATED WITH THE USE OF THE INTRATRACHEAL TUBE

Complications of intratracheal anesthesia are due principally either to the trauma of introducing the tube into some part of the respiratory tract which is not patent enough to accept it without injury to the tissue, or to compression of the tube during anesthesia The latter makes the method hazardous

*Nasal Intubation—Deviated Septum*—If deviation of the septum has not been recognized and if the anesthetist persists in attempting to pass a nasal tube on the concave surface of the deviated septum, it occasionally will be heard to crack It may be that some straightening of the septum occurs although I have no proof of that If a soft tube is forced, however into the narrow nostril without the septum giving way, then the tube will become compressed and respiratory obstruction usually develops under such circumstances The tube usually can be passed freely on the concave side of the deviated septum, therefore, care should be exercised to avoid the use of force in the introduction of the tube by the nasal route Pathologic lesions in the nose may be traumatized by the tube but I have not experienced that difficulty

complicated. The equipment consists of a metal T piece [fig. 387], a metal angle piece, suitable lengths of rubber tubing and Magill intratracheal tubes [fig. 388 *a* and *b*]. For infants up to two years, premedication with atropine only is used.

The routine employed by Ayre is first to anesthetize the infant with ether by the open drop method until adequate depth of anesthesia for intubation without trauma has been accomplished. A suitable size of intratracheal tube (No 0 to 2) is chosen and is inserted into the trachea by the oral route with the aid of a laryngoscope. The passage of the intratracheal tube through the vocal cords can

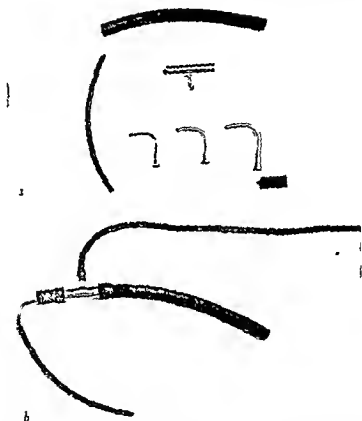


fig. 388—Ayre's intratracheal apparatus. *a*, component parts consisting of intratracheal tube, T-piece, three sizes of connecting pieces and large bore rubber, breathing tube. *b*, apparatus assembled. This shows the small rubber tube connected to the side arm of the T-piece through which oxygen and ether vapor are introduced.

be facilitated by the insertion of a blunt stilet within the intratracheal tube to increase its rigidity. This stilet should not project beyond the open end of the tube. Usually the tube is inserted about  $\frac{1}{4}$  to  $\frac{3}{4}$  inch (0.6 to 1.2 cm.) into the trachea. The stilet is then withdrawn. The end of the tube which protrudes from the mouth is then cut off level with the teeth and the small end of the metal angle piece is inserted well into it in order to prevent compression of the tube by the mouth gag or other instruments during the operation. The distal end of the angle piece is connected by about an inch (2.5 cm.) of rubber tubing to one of the

large open ends of the T piece To the corresponding end of the T piece is attached a rubber tube, about 10 inches (25 cm) in length and about 11 to 13 mm in diameter The distal end of this tube is open to the air to permit to and fro breathing To the small side inlet of the T piece is attached a rubber tube which delivers oxygen with ether vapor from any suitable apparatus used for this purpose

When the apparatus is in position, the angle piece is fixed with adhesive tape to the infant's chin and the T piece lies vertically below the chin The distal length of rubber tubing lies underneath the sterile drape in such a position that the outlet is free and the anesthetist can listen to the patient's respirations A fine strip of absorbent cotton or cleansing tissue can be fixed with adhesive tape over the end of the tube, and this will move to and fro with each breath and will aid in the observance of the patient's respirations It may be necessary to adjust the amount of rebreathing by altering the length of the rubber tube to suit the tidal volume of the infant

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*Bleeding*—The commonest symptom observed in the course of passage of a tube through the nose is bleeding, for slight trauma to the mucous membrane with the tip of the tube often causes bleeding. Such bleeding gives an appearance of injury which may be misleading in the average case. In my experience, I have not seen serious untoward results from nasal bleeding.

*Trauma to Vocal Cords*—In a rare case the surface of one or both vocal cords is traumatized and a small blister or hematoma appears which is usually associated with hoarseness. Occasionally when this has happened the patient has complained for months after operation of hoarseness and on examination a small lesion (granuloma) has been found on one or both vocal cords. In the few cases in which I have observed this result the oral surgeon has treated the lesion successfully with a protected diathermy needle. Whether or not the tube caused the lesion cannot be determined with any certainty since contact granulomas have been found in cases in which an intratracheal tube has not been used.

*Oral Intubation*—Trauma to the teeth may occur from the use of the laryngoscope for oral intubation, especially when there has been dental repair or when such repair is needed. The lips may be pinched between the teeth and the laryngoscope. The use of some protective device for the teeth is desirable. The tongue seldom gives trouble. The epiglottis, however, may be bent and traumatized by the end of the laryngoscope. The oropharynx may be traumatized by the end of the laryngoscope and, significantly, Sykes<sup>9</sup> speaks of "removing pharyngeal divots" with the laryngoscope.

*Mucus in Lumen of Tube*—Unless the mucus or foreign material that gathers or becomes lodged in the lumen of the tube is removed, it will complicate use of the tube. When the tube is not used and mucus is in the trachea, it frequently will be spilled over into the oropharynx or nasopharynx where it may lie without producing trouble. When such material occupies the lumen of the tube, it will be raised and lowered with each breath and will decrease greatly the respiratory exchange. It is more important to aspirate material from the intratracheal tube than from the trachea when the tube is not used but, of course, it is desirable to clear the airway in any event. Anesthetists are used to the bubbling sound of mucus moving back and forth in the trachea and when they hear the same sound in the tube, they are not as alarmed as they should be. It is important for the tube to be kept unobstructed because foreign material cannot escape by itself unless the patient is lying in the prone position and even then aspiration should be done. It may be easier to remove mucus if the tube has been greased inside than if this has not been done.

*Complications Caused by the Time the Tube Remains in Trachea*—The time that the tube lies in the trachea and larynx is usually relatively short. However in an occasional case I have had to insert a tube and

leave it in place for a number of hours. I have seen an untoward result only once when the tube was left in place for fifteen hours or less. At necropsy in some cases in which prolonged artificial respiration has been carried out and the tube has remained in the trachea for periods up to seventy or eighty hours, however, a membrane has been noted. This membrane was formed much like that found about a tracheotomy tube and in addition ulcers and discolored pressure areas were seen



Fig. 389.—The larynx and upper part of trachea in the case in which intra-tracheal tube was in place for about thirty-eight hours. The hemorrhagic exudate involving almost the entire circumference of the upper part of the trachea can be noted.

where the tube had pressed against the mucous membrane (figs. 389 and 390). To obtain the specimens from which figures 389 and 390 were made it was necessary to be on the watch for them over a period of years; artificial respiration is seldom continued for more than twenty hours because of the futility of anticipating a recovery in such a case. A lesion causing respiratory paralysis that does not respond to treatment within twenty hours may be considered fatal although in some instances I have carried on mechanical artificial respiration with

the intratracheal tube until the heart stopped, even though I was not hopeful of a satisfactory outcome.

**Comment.**—Complications following the use of the tube are more likely to be due to trauma associated with the introduction of the tube than to the tube's simply lying in the trachea for the period of the operation except when the technic recommended herein has not been followed. It is reasonable to assume that a tube that has not been thor-



Fig 390—(Same case as Fig 389) The destroyed epithelium of the trachea has been replaced by a heavy, thick exudate. This exudate and inflammatory reaction extends into the underlying tissues even down to the mucus-secreting glands. There is slight edema of the connective tissue between the glands and the destroyed epithelium ( $\times 50$ ).

oughly cleaned and sterilized or that has been lubricated with non-sterile petrolatum applied with a nonsterile sponge may introduce organisms foreign to the patient into the respiratory tree at a time when his resistance to operation and anesthesia is not adequate to overcome them.

Complications can be prevented to a large extent if the anesthetist will take precautions against contamination and employ the measures

that are advocated for the purpose of making the introduction of the tube relatively easy.

Another unusual complication which I should mention is hiccup. I have seen three or four patients who had hiccups with an intratracheal tube in place.

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# CONTINUOUS SPINAL ANESTHESIA· A NEW METHOD UTILIZING A URETERAL CATHETER

EDWARD B TUOHY\*

IN previous publications and communications,<sup>1 2 3</sup> Lemmon's<sup>4 5</sup> technic for continuous spinal anesthesia has been considered and credit has been given to him for initiating and proving that it is a safe and practical procedure. Since the introduction of the malleable needle and special mattress technic by Lemmon I have endeavored to find a method which would obviate some of the mechanical difficulties which are encountered with this method and I believe at this time that an improvement in the technic of continuous spinal anesthesia is available. It comprises the use of a number 4 ureteral catheter<sup>1 4 6</sup> instead of a malleable needle to deliver the anesthetic agent into the spinal subarachnoid space. The decided advantage of fractional or serial doses in continuous spinal anesthesia should be obvious since one may add the anesthetic agent as it is needed and dispense with the necessity of administering a large or relatively large amount of the anesthetic at one time—the single dose method. Continuous spinal anesthesia is particularly suitable for the following operative procedures: (1) repair of unilateral or bilateral hernia, regardless of whether it is primary or recurrent, (2) operations on the stomach or biliary tract in cases in which the patients are good surgical risks, (3) colonic operations such as combined abdominoperineal resection and (4) lengthy orthopedic procedures on the hip or lower extremities.

Operations which carry an increased likelihood of hemorrhage, such as splenectomy or cesarean section, should not be done under spinal anesthesia produced by either the single-dose or continuous method unless it is felt

particular case. Likewise, to spinal anesthesia done safely under, accomplished as method, one should

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mal toxicity. Some authors feel that procaine hydrochloride is a little safer than metycaine but clinically I have not detected any notable difference in the toxicity of these agents. I have used metycaine more frequently than procaine. The choice between these agents is of minor importance. Agents which have a prolonged anesthetic action such as pontocaine or nupercaine, obviously are not necessary.

#### TECHNICAL DIFFICULTIES

The mechanical or technical differences which I have encountered with the malleable needle technic should be pointed out so that the alternative procedure may be critically analyzed. The malleable needle will bend easily and thus may make lumbar puncture more difficult than it is when a more rigid needle is employed. In some cases it will be noticed that the arachnoid puncture is troublesome because the bevel of the malleable needle will not pierce the dura and the arachnoid easily. In a measure, the dura and arachnoid are pushed ahead of the needle without being punctured. Furthermore, several assistants are required to turn the patient onto his back after the puncture has been accomplished so that the needle will not be dislodged from the subarachnoid space. Although a malleable needle has been used with the continuous method of spinal anesthesia in many cases, the practice of leaving the needle in position in the spinal subarachnoid space for a protracted period causes more injury of the tissues than does a ureteral catheter.

#### THE URETERAL CATHETER TECHNIC

The following equipment is required when the ureteral catheter technic is employed:

- One 2 c.c. glass syringe
- One 24 gage hypodermic needle
- One skin dilator
- One 15 gage needle 3 to 3½ inches (7.6 to 8.8 cm.) long with a Huber point \*
- One number 4 nylon ureteral catheter (roentgenographic type) with a round tip
- Towels and drapes
- Two 2 c.c. ampules of a 10 per cent solution of procaine hydrochloride or metycaine hydrochloride (each cubic centimeter of a 10 per cent solution contains 100 mg. of the anesthetic agent)
- A 1 c.c. ampule of ephedrine sulfate (25 mg.)
- A 1 c.c. ampule of ephedrine sulfate (50 mg.)
- One two way stopcock
- One 10 c.c. glass syringe (Luer type)
- One 23 gage hypodermic needle with the point filed off
- One hemostatic forceps
- Two 20 gage needles 1½ inch (3.8 cm.) long
- Surgical antiseptic solution and sponge

The ureteral catheter is sterilized by autoclaving for ten minutes at a pressure of 15 pounds or by gravity irrigation with a 1:1000 solution.

\* A needle with a Huber point is manufactured by Becton Dickinson and Company.

of bichloride of mercury at room temperature for an hour and a half. Autoclaving, however, is preferable.

The 15 gage needle with a Huber point has the following advantages: 1. The sharp, smooth point pierces the tissues easily and the closed bevel thrusts the tissues aside. As a result, the puncture can be made more easily than it can with an ordinary needle and there will be less trauma and pain. 2. As the opening is on the side of the needle there is no possibility that it will become plugged with tissue when the stylet is in place. 3. The closed bevel permits a sturdy construction of the needle. 4. The design of the bevel of the needle enables one to direct the catheter either cephalad or caudad as desired. This is a decided advantage because with a conventional bevel there is no method of controlling the direction the catheter will turn when the subarachnoid space is reached. Thus, if it is desired that the catheter advance upward in the subarachnoid space the bevel of the special needle is turned cephalad and the catheter will by necessity advance upward when the catheter reaches the subarachnoid space. Conversely, if one desires that the catheter remain low in lumbar region, the bevel of the needle is turned toward the sacrum and the catheter will advance caudad.

The catheter is graduated in centimeter markings and at one end of the catheter there are ten small marks, which are tabulating aids in keeping count on the number of times the catheter is used. After each occasion that the catheter is used one of the ten markers is cut off. It is felt that the catheter should not be used more than ten times because it tends to deteriorate with repeated sterilization. The tensile strength of a new no. 4 catheter is about 50 pounds. Naturally, any defect noted in the catheter should be inspected and the catheter discarded if any doubt exists concerning its integrity.

The needle usually is inserted between the third and fourth or between the fourth and fifth lumbar vertebrae, occasionally, it is inserted between the second and third lumbar vertebrae and, rarely, it is inserted between the first and second lumbar vertebrae. The skin and subcutaneous tissue at the site of injection are anesthetized with a 1 per cent solution of procaine hydrochloride and 25 to 50 mg. of ephedrine sulfate is injected intramuscularly. A small skin awl or the tip of a Steinman pin is used to make a small opening in the skin to facilitate the insertion of the 15 gage spinal needle. The catheter should be checked carefully and one should determine whether it can be passed freely through the lumen of the needle. A flush fitting stylet is inserted into the lumen of the needle and the subarachnoid puncture is made. When the needle enters the intrathecal space, a definite snap may be felt. If the needle has entered the intrathecal space, spinal fluid will run out of the hub of the needle after the stylet has been withdrawn. The stylet should be replaced temporarily to prevent the loss of spinal fluid. The stylet then is withdrawn and the 10 c.c. Luer

syringe containing a 10 per cent solution of metycaine hydrochloride or procaine hydrochloride is attached to the hub of the spinal needle. A sufficient quantity of spinal fluid to effect the desired dilution of the anesthetic solution then is aspirated into the syringe. For example, if the syringe contains 3 c.c. of a 10 per cent solution of the anesthetic agent and one desires to employ a 3 per cent concentration, a sufficient quantity of spinal fluid to make a total of 10 c.c. is aspirated into the syringe and permitted to mix with the anesthetic solution. Each cubic centimeter of the resulting mixture will contain 30 mg. of the anesthetic agent.

The syringe is removed from the hub of the spinal needle and the no. 4 ureteral catheter is inserted into the lumen of the needle and is advanced slowly into the subarachnoid space. The centimeter markings on the catheter are used to measure the length of the needle so that one can determine how far to introduce the catheter into the intrathecal space. The round tip of the catheter is advanced sufficiently far beyond the end of the bevel of the needle into the subarachnoid space so that it will not slip out of position when the needle is removed from the intervertebral space. In most instances, the catheter should be advanced about 6 to 7 cm. beyond the point of the needle before one attempts to remove the needle. Inasmuch as the catheter is pulled back a little when the needle is slowly removed from the intervertebral space, one must allow for this deficit to insure that the catheter will remain in proper position. As soon as the needle has been removed from the intervertebral space and slid off the free end of the catheter, one may still adjust the position of the catheter in the subarachnoid space by pulling gently on the catheter. Obviously, one cannot advance the catheter after the needle has been removed but the catheter may be pulled outward without difficulty, in order to adjust the tip of the catheter to the desired level. In general, if the lumbar puncture has been made between the third and fourth lumbar vertebrae and if the catheter has been advanced upward in the subarachnoid space according to the foregoing technique, the tip of the catheter will lie midway on the body of the second lumbar vertebra. Under no circumstances should the catheter be pulled backward while the needle is in place because if this is done the catheter may be impinged against the bevel of the needle. The needle should be removed from the interspinous space before an attempt is made to withdraw the catheter.

The free end of the catheter is fitted with a blunt 23 gage hypodermic needle which fits the lumen of the catheter snugly. A two way stopcock is then attached to the hub of the needle and the glass (10 c.c.) syringe containing the anesthetic solution diluted with spinal fluid is attached to the other end of the stopcock. The initial dose of the anesthetic agent is usually 90 to 120 mg. of procaine or metycaine hydrochloride depending on the physical status of the patient. In general the initial dose should be a fifth to a fourth less than the dose

of bichloride of mercury at room temperature for an hour and a half. Autoclaving however is preferable.

The 15 gage needle with a Huber point has the following advantages: 1. The sharp smooth point pierces the tissues easily and the closed bevel thrusts the tissues aside. As a result the puncture can be made more easily than it can with an ordinary needle and there will be less trauma and pain. 2. As the opening is on the side of the needle there is no possibility that it will become plugged with tissue when the stylet is in place. 3. The closed bevel permits a sturdy construction of the needle. 4. The design of the bevel of the needle enables one to direct the catheter either cephalad or caudad as desired. This is a decided advantage because with a conventional bevel there is no method of controlling the direction the catheter will turn when the subarachnoid space is reached. Thus if it is desired that the catheter advance upward in the subarachnoid space the bevel of the special needle is turned cephalad and the catheter will by necessity advance upward when the catheter reaches the subarachnoid space. Conversely if one desires that the catheter remain low in lumbar region the bevel of the needle is turned toward the sacrum and the catheter will advance caudad.

The catheter is graduated in centimeter markings and at one end of the catheter there are ten small marks which are tabulating aids in keeping count on the number of times the catheter is used. After each occasion that the catheter is used one of the ten markers is cut off. It is felt that the catheter should not be used more than ten times because it tends to deteriorate with repeated sterilization. The tensile strength of a new no. 4 catheter is about 50 pounds. Naturally any defect noted in the catheter should be inspected and the catheter discarded if any doubt exists concerning its integrity.

The needle usually is inserted between the third and fourth or between the fourth and fifth lumbar vertebrae; occasionally it is inserted between the second and third lumbar vertebrae and rarely it is inserted between the first and second lumbar vertebrae. The skin and subcutaneous tissue at the site of injection are anesthetized with a 1 per cent solution of procaine hydrochloride and 25 to 50 mg of ephedrine sulfate is injected intramuscularly. A small skin awl or the tip of a Steinman pin is used to make a small opening in the skin to facilitate the insertion of the 15 gage spinal needle. The catheter should be checked carefully and one should determine whether it can be passed freely through the lumen of the needle. A flush fitting stylet is inserted into the lumen of the needle and the subarachnoid puncture is made. When the needle enters the intrathecal space a definite snap may be felt. If the needle has entered the intrathecal space spinal fluid will run out of the hub of the needle after the stylet has been withdrawn. The stylet should be replaced temporarily to prevent the loss of spinal fluid. The stylet then is withdrawn and the 10 c.c. Luer

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spinal anesthesia is 3 to 5 per cent. Postoperative urinary retention or dysuria was present in 2 per cent of cases in which this method of anesthesia was used. This percentage is almost the same as that for general anesthesia. There have been no instances of persistent paresthesia following the catheter technic. Tenderness at the site of lumbar puncture is encountered rarely and in most instances is attributable to technical difficulties in the performance of the lumbar puncture. For academic or investigational purposes, the position of the catheter may be checked by roentgenographic examination since the catheters are of the roentgenographic type. Furthermore, in the event that a catheter is inadvertently broken it can be identified roentgenographically. The possibility of breakage of a catheter is potentially present, but I do not believe that the hazard is as great as with a needle. In my experience and as far as I have been able to determine by communicating with other anesthetists who have used this technic, no instance of catheter breakage has occurred. Reasonable care in handling the catheter and careful inspection before its use are important. No more than ten anesthetics should be administered with one catheter.

There are few limitations to the catheter technic as I have used it. On occasion it has not been feasible to employ this technic for operations on the lower lumbar vertebrae (herniated nucleus pulposus or spinal fusion) because the catheter would encroach on the operative field. This limitation, however, was encountered also with the malleable needle technic. Of late, however, in certain cases I have made my lumbar puncture for operation of the type mentioned in the interspace between the first and second lumbar vertebrae with the bevel of the needle intentionally turned caudad and have had satisfactory results for anesthesia and no encroachment on the operative field from the catheter.

A decided advantage is gained in operation on peripheral nerves (sciatic, peroneal and so forth) with continuous spinal anesthesia when the patient must have a plaster spica cast applied after operation. The patient can be moved on to a special table for the cast, if needed, or the cast can be applied on the original table without fear of dislodging the catheter and thus risking the possibility of losing adequate anesthesia in due time. Deaneesthesia (Lemmon) is practical and easy to effect with the catheter technic and to-and-fro irrigation of the subarachnoid space with physiologic salt solution can be accomplished in most cases.

#### SUMMARY

Further encouragement is given to those who would employ continuous spinal anesthesia in suitable cases for long operative procedures especially those below the diaphragm. My experience and that of other anesthetists who have utilized the ureteral catheter technic indicates that this method has definite advantages over the needle technic and is practical. Technically, the procedure is not difficult and can be accomplished by physicians who are familiar with lumbar puncture.



performed in the conventional manner. The equipment necessary is relatively inexpensive (\$15.00) and occupies little space. Portability is a decided asset. Whereas nausea and vomiting occur occasionally with this method of spinal anesthesia, the potential dangers associated with single dose spinal anesthesia with larger doses of the anesthetic agent such as severe depression in systolic blood pressure and high dermatome levels of anesthesia, are rarely encountered. Sustained and adequate anesthesia is more certain by this procedure and greater operative flexibility is established.

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# CONTINUOUS CAUDAL ANESTHESIA IN OBSTETRICS

JOHN S LUNDY

CAUDAL anesthesia has been used for the relief of pain for a number of years but certain recent variations in the technique of its application have revived interest in it and extended its application. The introduction of long-lasting drugs and the various techniques of using rigid needles and making one injection, using a malleable needle or catheter for multiple injections as well as the method of continuously dropping the local anesthetic solution into the caudal canal have influenced this method. Its application to obstetrics has paralleled the various changes.

The use of caudal anesthesia alone or in combination with paravertebral block in obstetrics was suggested by Cleland<sup>1</sup> in 1933, but little attention was paid to his suggestion. In 1942 Edwards and Hingson<sup>2</sup> advocated the use of continuous caudal anesthesia in obstetrics and published the results of their trial of the method. The most outstanding influence in their development of the method was the work of Lemmon<sup>13</sup> who had suggested use of a malleable needle for maintaining continuous spinal anesthesia. Hingson, having used Lemmon's method for spinal anesthesia, employed a somewhat similar setup to produce continuous caudal anesthesia. He was goaded into this by Edwards' demand for a method of relieving pain in childbirth other than the conventional ones at that time.

At the time of their first publication on this subject Edwards and Hingson were not familiar with Cleland's work but as they searched the literature they came on more and more items that were directly and indirectly associated with their independent suggestion of using this method for the relief of pain during labor and delivery. Their enthusiasm for this method of analgesia in obstetrics was contagious for some<sup>4, 10</sup> but not for others. Much publicity occurred. Since part of it was lay publicity it did not encourage but rather discouraged many obstetricians from using the method. This reaction is understandable since caudal block is not safe in the hands of the untrained and few, if any, obstetricians at that time were interested or experienced in the use of caudal anesthesia. Some articles were published which denounced the publicity given the new method before it had had widespread trial.<sup>7, 19</sup>

To those few physicians who had had experience with caudal block anesthesia in both obstetrics and for surgical operations prior to Edwards and Hingson's publication in 1942, it seemed likely that in a certain percentage of obstetric cases continuous caudal anesthesia might be the anesthetic method of choice. Early in 1942 while I was preparing my textbook, "Clinical anesthesia," Hingson sent me this paper be-

fore publication for suggestions and advice. Because I felt that the method had a place, I mentioned in my textbook<sup>10</sup> the work I knew he was doing and was about to present as follows:

Improvements in obstetric anesthesia should be made and shortly an evaluation should be attempted of the safety of different agents and methods for different types of patients and varying physical conditions. There is a serious disagreement between those concerned with the problem as to the proper procedures to carry out and whether from the standpoint of the survival of mother and child one is justified in using anesthetic or analgesic substances in sufficient dose to give relief of pain in childbirth. It is most difficult for the obstetrician not to employ anesthesia because the patients demand it and if one obstetrician is unwilling to use anesthesia the patient usually will go to one who will use it. Personally I side with the patient and advocate the use of anesthesia in obstetrics. I believe it is possible that in time the obstetrician will be able to select for his patient the particular method that will be the safest for her and for her baby whether the method be Hingson's continuous caudal anesthesia, perineal block, rectal or inhalation anesthesia, sedation with barbiturates or morphine or both, or the combination of them all. Except in a very few institutions the obstetrician as a rule does not have as great a choice of anesthetic agents and methods at his command as does the surgeon.

By November 1944 enough information and experience had been accumulated concerning control of pain in childbirth so that Lull and Hingson<sup>15</sup> were able to publish a book in which they discussed the various methods that have been employed. They gave detailed instructions for and results of the application of the method called "continuous caudal analgesia."

It seems clear that the relief of pain in obstetrics can be carried out in a number of ways just as the relief of pain of surgical operation can be carried out in a number of ways. I believe that no one method should be used routinely either in obstetrics or in surgery. At the same time I believe that as many useful methods should be available as possible. I am, therefore, presenting a description of the technical application of continuous caudal anesthesia in obstetrics without advocating its routine use. For those who wish to review the accumulated experience with this method to date a reasonably complete and practical bibliography is appended.

In certain cases the obstetrician will wish to use continuous caudal analgesia for labor up to but not including actual delivery itself. It is possible, therefore, that some combination of caudal anesthesia with general anesthesia will be reported later. Actually there will tend to be as many opinions and as many techniques as there are users of the method. Each user may and no doubt will try to improve on the technique of someone else. This will be done many times without knowledge that someone else has already done it.

The publicity associated with the presentation of the work of Edwards and Hingson caused Adams and his co-workers<sup>1-3</sup> to investigate the method for possible refinements and he suggested the use of an in

dwelling catheter. His attention then was called to the use by Love<sup>14</sup> of an indwelling catheter for subarachnoid drainage and later he found that Manalan<sup>10</sup> had used the indwelling catheter and had demonstrated this method in October, 1940. Manalan's objective, however, was different from that of Adams. Manalan placed the catheter ahead of time and used only a single injection for actual delivery whereas the technic advocated by Adams was to produce continuous analgesia throughout labor as well as delivery.

It is not unusual for different individuals to come independently to similar conclusions as well as techniques. Interestingly enough following the use of the catheter for continuous caudal anesthesia, Tuohy (see page 834 of this issue) began to use the ureteral catheter for producing continuous spinal anesthesia. It is a logical procedure.

### CONTRAINDICATIONS

If good results are obtained from continuous caudal anesthesia they are dramatic and tend to make everyone enthusiastic. The patient is especially so, she demands it for herself thereafter and urges her friends to do likewise. It is well to mention Hingson's list<sup>17</sup> of patients for whom the method is contraindicated. These are as follows:

1. Patients with easy, almost precipitate labors and patients who come into the hospital in the terminal part of the second stage of labor, less than forty minutes before delivery—for them a few whiffs of gas or ether, and, in the selected short cases, even chloroform, are safer and more satisfactory than caudal analgesia. This group includes an estimated 10 per cent of hospital deliveries.
2. Patients who are apprehensive, nervous, and desirous of being asleep when the baby is born and those who profess a fear of caudal analgesia because of the needle injection or because it is to them an experimental procedure, do not as a rule make good patients under this technique and should be excluded. They represent about 10 per cent of hospital obstetric patients.
3. Gross deformities or disease of the spine or central nervous system, including syphilis of the central nervous system, tumors which narrow the spinal canal, abnormal extension of the spinal hiatus, low extension of the dural sac, histologically unstable personalities preclude the use of the method. On the basis of a study of several thousand sacra, estimated that more than 5 per cent have anatomic deformities in and around the sacral hiatus which would exclude successful use of the method. This group excludes an other 10 per cent.
4. Extremely obese individuals with large fat pads over the sacral hiatus preventing accurate palpation of the hiatus and adequate insertion of the caudal needle should not receive caudal analgesia. Approximately 3 per cent of patients can be listed in this group.
5. Local infection (bacterial or fungus) at the site of the injection and patients with real removed and potential pilonidal cysts contribute to another 2 per cent of the contraindications.
6. Profound anemia and dehydration unless supplemented by oxygen inhalations and intravenous fluids.

- 7 The obstetric complications can be grouped under one section
  - a Placenta previa unless used for immediate cesarean section
  - b Abruptio and incomplete or beginning premature separation of the placenta
  - c Patients with definite disproportions of pelvic and fetal diameters unless used for a trial of labor preliminary to a cesarean section
  - d Nulliparous patients with a floating and unengaged fetal head and patients with pendulous and weak abdominal walls in the presence of an unengaged fetal head
  - e In the birth of monstrous and predetermined dead babies
 Approximately 5 per cent of hospital deliveries fall into this group
- 8 History of sensitivity to the analgesic agent is an extremely rare but, indeed definite contraindication

### TECHNIC

Several techniques may be employed in producing continuous caudal analgesia. The two methods most commonly used employ (1) the malleable needle and (2) the ureteral catheter. The technic employed at the Mayo Clinic is as follows:

The solution usually has been a 1.5 per cent solution of metycaine with epinephrine. It is prepared by placing in a small measuring cup 5 c.c. (1 gm.) of 20 per cent metycaine and adding 1 c.c. of 1:2,600 epinephrine and 60 c.c. of sterile triple distilled water. The patient is placed on her right side in the Sims position. The right-handed anesthetist stands facing the patient. The patient is brought close to the edge of the bed so that the anesthetist can easily reach the sacral region. The sacral region is cleansed with soap and water, dried and painted with two or three coats of an antiseptic, such as tincture of metaphen, tincture of merthiolate and quaternary ammonium compounds (phemerol or zephiran chloride). More care must be used about asepsis for this procedure than for sacral block for ordinary surgical operations since the surgical patient is usually not in pain and is not in bed at the time the procedure is carried out. The field is draped with sterile towels and the patient's legs are covered with two extra towels so that there is plenty of sterile surface on which to lay out whatever long material, such as a catheter or tube, is going to be used.

The sacral hiatus is palpated in order to determine whether the canal is easily palpated and will probably be entered easily as it is in a relatively thin patient or whether difficulty may be expected like that encountered when the patient is obese. For the latter type of patient the catheter method is preferred because the needle through which the catheter is introduced is strong and stiff and one can be almost certain that after it enters the tip of the caudal canal the posterior wall of the caudal canal can be contacted. Such contact gives assurance that the needle has entered the canal. The malleable needle bends so easily that if any difficulty is encountered in introducing it into the tip of the canal, probing for the posterior wall of the canal may become difficult. On the other hand on certain occasions the malleable

needle should be used for the obese individual and the development of anesthesia should be depended on to prove that the needle is in place.

The selection of the method is stressed because the obstetric patient is unlike the surgical patient with respect to infections that may develop if excessive trauma occurs in connection with the introducing of the needle into the caudal canal. For example if a large needle used in connection with the introduction of a catheter is not easily introduced on first attempt, the anesthetist usually is well advised to discard the method in that instance. As few as three attempts to introduce the large needle have resulted in infection within the caudal canal in at

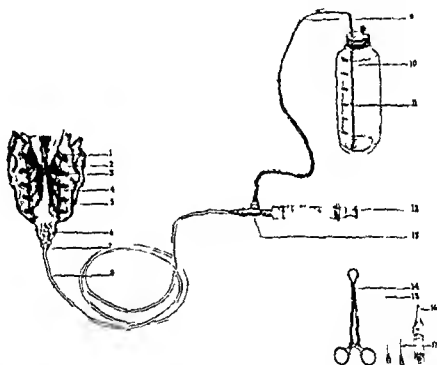


Fig. 391—The Hingson and Edwards apparatus for continuous caudal anesthesia, showing the relationship of the needle to the sacral nerves in the caudal canal (with author's permission)

least two instances which I have known about. It was in the hope that this handicap might be overcome that experiments were carried out incorporating penicillin in the solution containing the local anesthetic and epinephrine. This effort is reported on pages 775 and 776 of this volume.<sup>17</sup>

**Malleable Needle**—Figure 391 in general indicates the method of using the malleable needle and rubber tubing. The tip of the coccyx is palpated and a spot in the mid-line about half the length of the patient's index finger from the tip of the coccyx is located with the anesthetist's thumb. This spot is palpated with the pad of the index or middle finger and a drop of water is placed on it over the estimated

site of the sacral hiatus. The left posterior iliac spine is palpated and the midline is observed. A drop of water is placed a fingerbreadth in and a fingerbreadth caudad from the posterior superior iliac spine and a good fingerbreadth from the mid line. It should overlie the left second sacral foramen. A second drop of water is placed a fingerbreadth caudad to this one. This second drop should overlie the left third sacral foramen. Another drop is similarly placed to overlie the left fourth sacral foramen. A line drawn through these three drops tends to parallel the edge of the sacrum, that is, the drop over the second foramen will be a bit further from the midline than the drop that overlies the fourth so that if drops were in place on both sides of the sacrum they would make a wide V pointing toward the coccyx. This maneuver is carried out quickly, of course. These measurements upward from the tip of the coccyx and downward from the posterior superior iliac spine will indicate closely the tip of the caudal canal. When the opening of the canal is difficult to palpate, location of the landmarks just mentioned is the only way by which the anesthetist has a reasonably good chance of finding the canal with the needle. A wheal is raised in the skin overlying the estimated location of the sacral hiatus and a small needle usually 20 gage  $1\frac{1}{2}$  inches (3.7 cm) long is attached to the syringe containing the local anesthetic solution. The anesthetist's left hand steadies the skin overlying the sacrum, the tip of his left middle finger usually immobilizes the wheal in the skin and presses on the tissue immediately cephalad to the opening. Pressure of the fingers of the left hand in this way aids in forcing the needle into the opening of the caudal canal. The anesthetist should hold the syringe in his right hand as one would hold a dart that is to be thrown. The bevel of the needle should be toward the bone so that the point of the needle will not engage itself in bone and periosteum. The right hand rests on the patient's buttock so that if she moves his hand will move with her and protect the needle against breakage. The small needle is inserted over the superior surface of the tip of the sacrum and usually into the sacral hiatus and the tip of the caudal canal. About 2 c.c. of solution is deposited in the tip of the canal. The amount of solution injected through this first needle should always be small so that if the needle should enter a vein only a mild systemic effect will be produced. This effect usually consists of tremor, dyspnea, fall in blood pressure, slowing of pulse and apprehension. If large quantities, that is 5 to 10 c.c., were injected, a convulsion might follow immediately. It is a worth while precaution, therefore, to have a 10 or 20 c.c. syringe filled with 2.5 per cent solution of pentothal sodium at hand. A small quantity, 2 to 5 c.c., of pentothal solution injected intravenously will control most convulsions due to the systemic effect of the local anesthetic.

The syringe is disconnected from the small needle. The needle, however, is left in place as a marker. The malleable needle, preferably a new one is picked up by the anesthetist in his right hand. He holds

the shoulder of the needle between the tip of the middle finger and thumb and with his index finger forces the stylet into the needle. This grip on the needle is important since introduction of the point of the needle into the caudal canal is much more successful if continual pressure is exerted by the right index finger from the moment the needle is pressed against the skin until it finally enters the canal. With the needle gripped in this fashion, the anesthetist must immobilize the skin over the sacrum with the left hand as before, the short needle is removed and the malleable needle is then inserted with the bevel away from the bone until the bone is contacted. The needle is then given a half turn, the bevel is brought against the bone so that it will slide over the bone readily and the tip of it will not become engaged with the bone. If the needle catches in the bone it will bend and the anesthetist cannot be sure of controlling it.

If the needle enters the canal, on some occasions the anesthetist can feel the point of the needle striking the posterior wall of the canal. This feeling gives assurance that the needle is in place. If the needle overrides the sacral hiatus and does not enter the canal but slides close to the bone along the posterior surface of the sacrum, the patient will complain of severe pain and resistance to advancement of the needle will be great. If the sacral hiatus is missed by a wider margin than when the needle clings to the bone, then the needle may be advanced until its point comes near to the surface. The skin will become elevated by the needle and the point of the needle can be palpated. Solution injected here, of course, will raise a lump. If the anesthetist is certain that he is outside of the caudal canal, he may inject a little air rather than solution in an attempt to minimize the amount of concentrated solution injected in a spot where caudal analgesia will not be produced by it.

If the needle has entered the caudal canal then the stylet of the needle is withdrawn. The next step is to attach the syringe containing the local anesthetic solution to a short piece of small rubber tubing which is attached to the hub of the needle. Five tenth cubic centimeter of the solution is injected to be sure that the needle is clear and then aspiration with the syringe for blood is carried out. If none is obtained, more solution is injected slowly. The rate of injection should be as slow as that which would be used if the anesthetist were sure that the needle was in a vein and he wished only to produce a minimal reaction to the local anesthetic injected. If 5 or 10 c c. of the solution is well tolerated by the patient, then it is safe to assume that the tip of the needle is not in a vessel. A long piece of tubing is attached to the needle. The method illustrated in figure 391 or any other arrangement can be utilized so long as the syringe can be connected to the needle within the caudal canal by means of the tubing. The tip of the tubing, of course, will have to be kept clean if the syringe is to be detached from it. This can be done as shown in figure 392 by using a



metal adapter on the end of the tubing and applying a metal cap to the adapter. The needle is fastened to the patient with adhesive tape and the tubing is brought up to the patient's side, covered with gauze and held in place with adhesive tape. The remainder of the first injection is then made. The total amount of solution injected at the first injection usually is 30 c.c. If the solution enters the canal, relief of pain occurs rather early.

The patient should then lie on one side or the other rather than on her back. She should particularly avoid sitting up because by doing this she not only may break the needle but may move it farther up the canal than when the first injection was made and the point of the

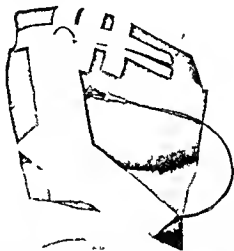


Fig. 397.—The exit of the catheter from the skin is thoroughly fixed with water proof adhesive tape both to hold it in place and to prevent contamination of the point of exit by soiling. The catheter is carried across laterally and fixed to the skin over part of its length by adhesive stripping. A Luer needle has been inserted into the distal end of the catheter and fixed in place by a small piece of adhesive tape. Between injections the hub of this needle is protected and kept sterile by a Luer cap. The end of the catheter is carried around to the flank so that it rests in accessible position for repeated injections.

needle may enter a vessel. If it should enter a vessel, convulsions and unconsciousness may occur without warning on any subsequent injections of the anesthetic solution. The danger of a needle moving and entering a vein is one of the disadvantages of the technic in which the needle is used.

The patient should not be allowed to sit up for another reason. If she sits up her full weight will be resting on tissue that is anesthetized and she will not feel the sensation of continuous pressure. If the tuberosities of the ischii press on the buttocks long enough necrosis of the skin and tissue overlying these tuberosities may occur and two sores each about the size of a fifty cent piece, may result. Such lesions are

very slow to heal and puzzling to the person who does not understand their cause

The skin on the patient's abdomen should be tested for anesthesia. The level of anesthesia should not rise above the umbilicus because the contractions of the uterus then may be interfered with. This danger has been pointed out in many instances. Theoretically skin anesthesia to just below the umbilicus or to the level of the eleventh thoracic nerve is necessary for complete relief of pain. Nevertheless, I have observed more or less complete relief of pain even when there was little or no skin anesthesia in the abdominal wall. I have seen a great deal of immediate relief even from the first 2 or 3 c.c. injected with the first needle before the caudal needle was introduced but, in general anesthesia of the skin of the lower part of the abdominal wall occurs after good general relief of pain of labor. Intermittent injections of 25 or 30 c.c. of anesthetic solution are carried out at intervals one to one and a fourth hours for the average patient when epinephrine is used. When it is not used the anesthesia does not last as long. Some times it lasts only forty-five minutes. There does not seem to be an accumulation of toxic effect from the local effect because when the anesthesia disappears the local anesthetic has been absorbed and destroyed.

In some cases after a period of many hours the needle may slip out of the canal enough so that anesthesia becomes unsatisfactory. A poor connection between the tubing and the needle may allow the solution to escape from the system and not enter the caudal canal. I personally know of no instance in which the needle has found its way through the dura and into the spinal fluid if it was in proper place when the needle was initially introduced into the canal. If spinal fluid is obtained from the needle then use of the method without a doubt is contraindicated because spinal anesthesia will be produced and if a quantity of solution is injected the anesthesia may include all of the spinal nerves and may be fatal.

**With Catheter**—The patient is prepared as described for the malleable needle technic and the solution and the technic also are the same up to and including the insertion of the  $1\frac{1}{2}$  inch (3.7 cm.) 20 gage needle. At this point a large bore needle illustrated in figure 393 is used. It is inserted with the stylet in place in the same fashion as the malleable needle except that the contacting of the posterior wall of the caudal canal is more likely with this needle than with the malleable needle because it does not bend. The catheter to be used should be a no. 4 roentgen ray type of ureteral catheter. The markings on the catheter are important in bringing the point of the catheter to the right height within the canal. It is almost impossible to insert an unmarked catheter properly except by fortunate accident. The catheter should be tested to see that the lumen is patent by injecting solution through it. The ability of the catheter to pass through the large caudal

needle which is to be used should be tested before the needle is introduced into the patient. The catheter need not be long. The ordinary ureteral catheter which is 28 inches (71 cm.) long is sufficiently long so that it can be cut into two equal parts and each half will make a satisfactory catheter for insertion.

After the large needle has been inserted into the canal, the stylet is withdrawn. The anesthetist should measure with the stylet to see that the point of the needle is at least as high as the third sacral foramen and may be as high as the second. A length of catheter equal to the length of the stylet of the needle is measured off and placed on top of the needle and the skin of midline overlying the tip of the caudal canal. This will show again where the tip of the needle is within the



Fig. 393—The needle has been inserted into the caudal canal up to the level of the third sacral foramen. The stylet has been partially withdrawn.

caudal canal just as was done with the stylet. By observing the markings on the catheter at the point where the caudal needle disappears beneath the skin and where the original wheal was raised over the sacral hiatus, the anesthetist knows just how much catheter should lie outside of the skin. The catheter is threaded through the needle into the canal and then the needle is withdrawn gradually over the catheter. To do this the anesthetist holds the catheter with the right hand and pulls and rotates the needle with the left. After the needle has been withdrawn, the markings on the catheter will show that the catheter has been introduced much farther up into the canal than would be expected. The catheter then must be retracted gradually until the mark previously noted appears through the perforation of the skin that was made by the needle. When this has been done, the tip of the catheter lies exactly where the point of the needle had been placed. This is an important point in the technic since if the catheter is inserted much too

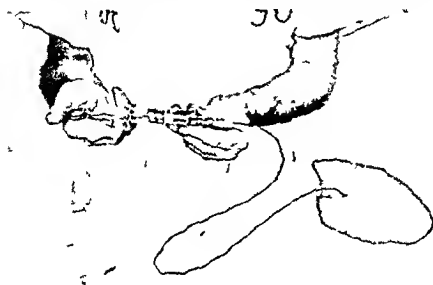


Fig. 394—Preliminary injection of metyrene through the catheter into the caudal canal prior to the fixation of the catheter with adhesive tape

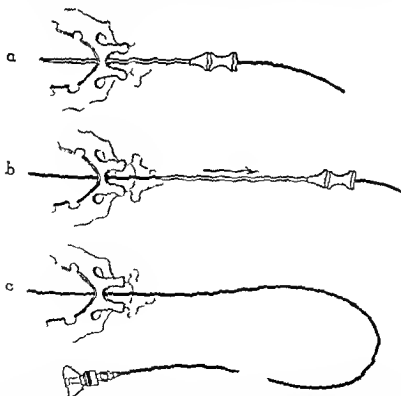


Fig. 395—The relationship of the 13 gauge needle and that of the catheter to the caudal canal *a*, needle in place, catheter inserted through needle so that point of catheter is flush with the point of needle. *b*, catheter held in place and needle being withdrawn *c*, catheter in place needle has been removed

high the tip of it will lie up in the lumbar region and an unsatisfactory result will be obtained

A small gage needle is needed to enter the inner orifice of the catheter and a small diaphragm of rubber, such as may be obtained from the top of a Baxter bottle of parenteral fluids or some other disk of thin rubber about the size of a fifty cent piece, should be used. The needle is inserted through the center of the rubber diaphragm and then into the lumen of the catheter. The rubber diaphragm is passed down over the catheter until it touches the skin of the patient near the place where the catheter passes into the skin. At this point the skin is painted with mastic in benzene (mistisol) or some other skin glue

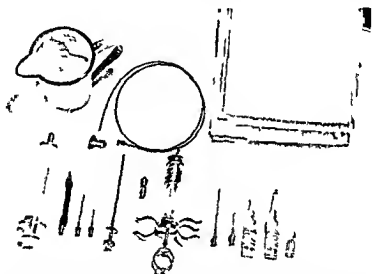


Fig. 396—Tray containing sterile equipment for continuous caudal anesthesia. The Lundy syringe, needles and Lundy Luer adapter may be omitted from this tray and only the Luer syringe and needles may be used for the preliminary infiltration, but the use of the Lundy Luer syringe facilitates the accomplishment of the first part of the injection.

and the rubber diaphragm is held against the skin for a few minutes until it becomes firmly attached. This makes a good tight cover and is an important step in the technic since the needle that was inserted into the caudal canal is much larger than the catheter and occasionally there is a tendency for the fluid that is forced through the catheter to return to the outside along the catheter and not to stay within the caudal canal.

The catheter is secured with strips of adhesive tape to the skin overlying the sacrum and a small piece of gauze is rolled up in the shape of a cigaret and placed on either side of the catheter and on top of the rubber diaphragm. The buttocks are then drawn together with adhesive tape. Figure 394 illustrates the injection of 30 c.c. of solution

through the catheter. The needle on the end of the catheter is capped with a metal piece as shown in figure 392 between the injections. The catheter then may be brought up over the patient's loin to her side and the whole of it secured with a long wide piece of adhesive tape so that the catheter is secured to the patient over its whole length and no loop of it can be caught. This is a change from the position of the catheter as shown in figure 392. The several steps already described are outlined in figure 395.

A word of warning from the standpoint of asepsis should be given. The type of syringe used makes a difference in the technique to be employed. The glass and metal syringe shown in the center of figure 396 keeps the plunger protected from contamination. When the all-glass syringe shown at the left of figure 396 is used, the plunger may easily become contaminated. After the plunger has been pulled out and pushed in again for the first time, it may become contaminated and in turn may contaminate the barrel during subsequent periods of use. Considerable care, therefore, must be exercised to avoid contamination as infection might result.

#### SOLUTIONS

Siever and Mousel<sup>1</sup> used 1.5 per cent solution of procaine hydrochloride rather than 1.5 per cent solution of metycaine. In a later report Siever<sup>20</sup> indicated that he has tried metycaine as well and tetracaine hydrochloride (pontocaine hydrochloride) in 0.25 per cent solution and still preferred the procaine. An outstanding point in Siever's report is that he found that procaine produced less untoward effect on the baby than other agents did. Brown and his co-workers<sup>11</sup> have utilized dilute solution of pontocaine with epinephrine and were able to produce several hours of anesthesia with one injection. They have repeated the injection as needed without leaving the needle in place. They reported good results. Hingson reported that he does not use epinephrine with the solution.

#### COMMENT

In the presence of eclampsia the patient's blood pressure tends to rise markedly when she is suffering from pain of contractions. However, as soon as the pain is relieved, the blood pressure drops or remains at set levels. As the anesthesia wears off and pain returns, the blood pressure quickly becomes elevated again. In cases of eclampsia epinephrine usually should not be used.

Continuous caudal analgesia should be carried out only by those who understand how to use it. The dangers associated with it in general are technical ones although the question of drug sensitivity is bound to come up from time to time.

It is as true in obstetrics as it is in surgery that the anesthetic should be fitted to the patient rather than the patient fitted to the anesthetic.

Those who have become habituated to using one or two methods of anesthesia in obstetrics will not differ much in their reactions from the surgeon who is accustomed to one or two methods of anesthesia. The tendency is to attempt routine use and especially to avoid any new method even after it has become pretty well worked out. There are advantages and disadvantages under these circumstances. The advantage is that it is much better for a physician to use an anesthetic method that he knows how to handle rather than to attempt to use several and have little skill with any of them. However, in institutions with good departments of both obstetrics and anesthesiology, continuous caudal anesthesia seems to have a possible usefulness in about a third of the obstetric cases. Variations in the way in which the method is applied are bound to happen. Some obstetricians will prefer to use caudal anesthesia for the terminal phase of delivery only.<sup>5</sup> It was for this purpose that Manalan<sup>18</sup> originated the indwelling catheter and put it in position sometime before it was actually needed. As I said before some obstetricians prefer to use inhalation anesthesia as a terminal measure and continuous caudal analgesia during the long hours of labor preceding delivery.

The method is relatively new and it remains for time to tell what its place will be in medical practice. However, I do not doubt that it is a valuable addition to methods of anesthesia and that it will be the method of choice in many obstetric cases.

For general surgery the continuous caudal method may be indicated occasionally. For example for hemorrhoidectomy or operations on the perineum when the patient is sensitive to morphine it is possible to leave the catheter or needle in the caudal canal for the first day after operation and to inject some local anesthetic occasionally rather than to depend on morphine. It is useful too when it is known that the operation will be prolonged and that anesthesia from a single injection might not last long enough. There may be other uses for the method such as in treatment of immersion foot or similar conditions when prolonged relaxation of the blood vessels in the extremities is needed. It might possibly be used in an occasional case of vascular disease of the extremity to determine the degree of involvement of the vessels.

The method is still new enough so that all of its possibilities have not been recognized.

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# ANESTHESIA FOR OPERATIONS ON THE PERINEUM

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THE perineum and its adjacent structures comprise one of the most complicated anatomic regions of the body. This region contains many of the organs of excretion and reproduction. The various functions of these organs are very important to the health of the body. As a result of the anatomic arrangement of the perineum and the function of the organs which it contains, this region is the site of a great variety of pathologic conditions, many of which can be treated surgically.

The male urogenital tract may be the site of many pathologic conditions, such as stricture of the urethra, prostatic hyperplasia and dysfunction, and calculi. Among women, many types of dysfunction are associated with the menstrual cycle and with sexual activity in general. In addition, a large group of pathologic conditions, such as cervical laceration and erosion, perineal relaxation, procidentia, rectal and vesical incontinence and vesicovaginal and rectovaginal fistulas occur as a result of pregnancy. Surgical conditions due to developmental defects are fairly common among both sexes. The incidence of malignant and benign tumors of the reproductive organs is rather high in both sexes. Diseases of the anus and lower part of the rectum are rather common, particularly among adults.

It is obvious that pathologic conditions of the perineum may be complicated or uncomplicated and may affect patients of any age. Some of these conditions are relatively localized and do not grossly affect the general health of the body. Others, for example, acute urinary retention, may result in marked chemopathologic changes throughout the body as a whole. Therefore, from the standpoint of the anesthesia, the problems involved may be simple or complicated, and will include those associated with the anesthetization of patients of all ages, in particular, those at the extremes of life. Since this anatomic region contains many orifices, endoscopic examination and manipulation frequently necessitate the use of additional anesthesia.

Fortunately, the relationship of this region of the body to the central nervous system and the fact that it is localized and at a distance from the respiratory tract make the use of a great variety of anesthetic procedures possible.

## TOPICAL AND INSTILLATION ANESTHESIA

There are a few procedures that can be carried out on this region without causing the patient pain or discomfort unless some type of anesthesia is employed. Vaginal examination and removal of a small specimen of the cervix for microscopic examination often can be ac-

complished with only slight discomfort. As many anesthetic agents and methods now are available, there is no justification for hurting a patient even for such minor procedures as examination and venipuncture. However, many minor procedures may be carried out by the topical application of a local anesthetic agent or its instillation into the urethra and bladder. One anesthetic technic for cystoscopic examination includes the instillation of 1 ounce (30 c.c.) of a 1 per cent solution of cocaine into the urethra and bladder and the application of a 10 per cent solution of cocaine to the urinary meatus. Some surgeons prefer to use other anesthetic agents such as a 1 per cent solution of diothane hydrochloride for this purpose. It is somewhat easier to obtain adequate anesthesia in women than it is in men.

By and large, this type of anesthesia is effective only for simple examination, manipulation and catheterization. The topical use of cocaine has been criticized owing to its potency and the occasional occurrence of untoward reactions. The possibility of such reactions must be kept in mind. To prevent such reactions or to minimize their severity, one should employ the lowest concentration of the drug that will produce adequate anesthesia. In addition, the dose should be kept as small as possible. A small amount of the solution should be instilled and, before instilling the rest of the dose, one should wait a sufficient length of time for an untoward reaction to become evident. If these precautions are observed, the incidence and severity of untoward reactions will be no greater than they are after the topical use of other anesthetic agents. The anesthesia produced by cocaine is more satisfactory than that produced by the topical use of most of the other anesthetic agents that are used for this purpose. A barbiturate should be administered as a premedicant, just as it is before the use of other types of local and regional anesthesia. A barbiturate always should be kept available for intravenous injection and equipment for administering oxygen should be kept handy.

#### LOCAL AND REGIONAL ANESTHESIA

The region of the perineum is not a very desirable place for infiltration anesthesia. There frequently is infection about the operative site, which makes the use of infiltration anesthesia inadvisable. Many surgeons do not favor the distortion which results from extensive infiltration. This is particularly true in cases in which plastic operations are performed about the anal outlet or on the vaginal outlet and perineum. Infiltration anesthesia is suitable for the removal of certain noninfected cysts or other circumscribed nodules. By employing suitable infiltration at the base of the penis, good anesthesia for a circumcision can be attained without distortion of the foreskin. With suitable infiltration of the scrotum and injection of the anesthetic solution into the structures of the spermatic cord, vasectomy, epididymectomy and orchectomy can be carried out.

**Regional Nerve Block**—With the exception of caudal sacral block (which is of sufficient importance to require special consideration), the blocking of individual nerves or groups of nerves in the perineal region has little to offer in this field. Bilateral block of the pudendal nerves may provide sufficient anesthesia for operations on the vaginal outlet but there are many other methods which seem to be superior.

### INHALATION ANESTHESIA

The choice of general anesthesia in preference to local, regional or spinal anesthesia for perineal operations depends to a great extent on individual preference and experience with a certain method. Most women prefer to be asleep for operations on the perineum and genitalia. Certainly, unless some systemic disease or pathologic process contraindicates general anesthesia, practically all of these operations can be carried out under it. Problems related to the airway are encountered less frequently in this type of operation than they are in operation on the upper part of the abdomen, thorax or upper part of the respiratory tract. Unless the operation requires opening the peritoneal cavity, as does a vaginal hysterectomy, or is performed on a region such as the anus where reflex activity is great, a light plane of general anesthesia is sufficient.

Many minor operations may be performed with nitrous oxide-oxygen anesthesia only or with ethylene and oxygen. More extensive operations may require the addition of some ether. Cyclopropane anesthesia is suitable for many procedures. In many cases in which the patients obviously are poor surgical risks this type of anesthesia is of value as it has little tendency to produce toxic effects on the liver, kidneys and respiratory system. On the other hand, many anesthetists feel that the inflammable and explosive nature of ethylene and cyclopropane have precluded their use for perineal operations because various types of electric equipment commonly are used.

Although the relative merits of inhalation and other methods of anesthesia may be left as a debatable subject and open to individual preference in cases in which the patients are adults, inhalation anesthesia is used almost routinely in cases in which the patients are children. For most operations on the genito-urinary system, including operations for epispadias, hypospadias and undescended testis, I employ nitrous oxide, oxygen and ether if the child is three years or more of age. For younger children, I prefer to administer ether by the drop method with an open mask. Some anesthetists prefer ethyl chloride for induction or prefer to use diethyl ether. In the hands of the average anesthetist, administration of ether by the drop method has a wider margin of safety than do the more potent agents which have just been mentioned.

There are a few operations in which the administration of an inhalation anesthetic with an endotracheal tube may be the method of

choice. One example is an operation for the repair of a vesicovaginal fistula with the patient in the prone position and her hips elevated on a sacral rest. The operation often is long and tedious and the position is uncomfortable especially if the patient is awake, as she is when regional or spinal anesthesia is employed. The position of the patient's head may make it difficult to maintain a free airway. The use of an endotracheal tube, which is connected to the gas machine before the patient is turned in the prone position, provides a method which offers better continuous control than does any other method.

For operations on the anus, it is generally felt that inhalation anesthesia is of no advantage but has many disadvantages. The reflexes of the anal region remain active, even when deep general anesthesia is employed, and good relaxation which is important in operations on the anal region, is difficult to attain. In other words, the necessary plane of anesthesia is out of proportion to the type and duration of the operation.

#### SPINAL ANESTHESIA

The advantages of so-called low spinal anesthesia for perineal operations have been evident for many years. Many of the factors which are responsible for the disadvantages and untoward effects of spinal anesthesia may be minimized when it is used for perineal operations. The required dose of the anesthetic agent usually is small, which tends to minimize the toxic effects. One of the lower lumbar interspaces (usually the one between the third and fourth lumbar vertebrae) is used. Since only a small volume of the anesthetic solution is required, the height of anesthesia is usually minimal. By using a small volume of solution of procaine hydrochloride or meprocaine, the concentration of the anesthetic agent in the spinal fluid can be kept at about 5 per cent, which will produce anesthesia of adequate duration even when comparatively small doses are employed. Since the degree of sympathetic and intercostal paralysis depends largely on height of the anesthesia, the degree of circulatory and respiratory insufficiency associated with low spinal anesthesia usually is less than that associated with spinal anesthesia for operations at a higher level.

The use of low spinal anesthesia for transurethral prostatic resection has become a standard procedure in many hospitals. Many patients who require this operation are elderly men who have toxemia, a high concentration of blood urea and varying degrees of cardiac, hepatic and renal insufficiency. Procaine hydrochloride, although not as potent as some other anesthetic agents, will produce anesthesia of sufficient duration for this type of operation. The dose ranges between 70 and 90 mg. and the drug should be mixed with 2 c.c. of spinal fluid. Even patients who are in a serious physical condition usually tolerate this dose well. If the patient is an elderly man who has serious cardiovascular and renal disease, a dose of procaine hydrochloride as small as 70 to 90 mg. may produce certain variations in the blood pressure. An

acute decrease of the blood pressure usually can be controlled by the intravenous administration of ephedrine or fluids. In certain cases the blood pressure may increase drastically. The mechanism of this increase is difficult to explain. If this increase persists, it may be necessary to administer amyl nitrite by inhalation. If this does not control the blood pressure sodium nitrite should be administered intravenously.

A word of caution may be in order regarding the management of variations in the blood pressure. When the blood pressure either falls or rises without apparent reason (such as loss of blood), it usually is best to withhold supportive measures for a short time in order to determine whether the blood pressure will become stabilized. If this precaution is ignored, a falling or rising blood pressure may be overcompensated and a vasodilator or vasoconstrictor may have to be administered subsequently. Drastic variations in blood pressure thus occasioned are much more deleterious to sclerotic vessels than are moderate degrees of depression or elevation.

In choosing the method of anesthesia for various perineal operations, the benefits of spinal anesthesia should at least be considered.

The relative merits of spinal anesthesia and caudal sacral block in cases in which rectal or anorectal operations are performed by the perineal approach have been argued for many years. Both methods have their adherents but surgeons who have performed such operations with caudal sacral block dislike to employ any other method of anesthesia for these operations. Both methods produce satisfactory anesthesia and the advantages of caudal sacral block over spinal anesthesia are mainly those of an extradural procedure over an intradural one, that is a fall in blood pressure occurs less frequently, the general systemic effects are less severe, and so-called spinal headache does not occur. Whichever method one prefers, there are certain indications for spinal anesthesia. These include infectious conditions over the sacrum, pilonidal cysts and similar conditions in which the injection might spread the infectious process. Minimal doses (35 to 70 mg of procaine hydrochloride or metycaine in 2 c.c. of spinal fluid) injected between the third and fourth lumbar vertebrae usually will produce anesthesia which will last at least one hour.

Operations for these lesions, like certain other types of perineal operations, usually are performed with the patient in the prone position with his hips elevated on a sacral rest. If procaine hydrochloride or metycaine is administered according to the technic which I have described, the injected solution is only slightly heavier than spinal fluid, therefore, by and large, the position of the patient may be disregarded during the operation. However, it has been found that there are better stabilization of blood pressure, less systemic effect (nausea and so forth) and less tendency for the level of spinal anesthesia to creep cephalad if the patient is kept in the horizontal position for from

ten to twenty minutes after the solution is injected. If this procedure is followed, the comfort of the patient will be increased and his general condition will be good during the operation. This effect probably is the result of the stabilization of the level of the anesthesia together with the complete obliteration of impulses before the patient is moved or disturbed in any way.

### CONTINUOUS SPINAL ANESTHESIA

With the exception of extensive plastic operations or the repair of rectovaginal or vesicovaginal fistulas, most of the operations performed by the perineal approach are not of sufficient duration to warrant the use of continuous spinal anesthesia. If continuous spinal anesthesia is indicated, the use of the needle technic may be somewhat complicated by the position of the patient. The catheter technic, as advocated by Tuohy,<sup>4</sup> would seem to have certain advantages. In brief, this modification of Lemmon's<sup>3</sup> method of continuous spinal anesthesia, consists of the introduction of a large caliber needle into the subarachnoid space through which a ureteral catheter is threaded and advanced so that its point comes to lie well within the spinal subarachnoid space. The needle is then withdrawn, leaving the catheter in place. The catheter is strapped at its site of entrance in the skin and the distal end, into which a needle is inserted for attaching the syringe, is carried upward along the patient's back to the head of the table. This method of continuous spinal anesthesia does not necessitate the use of special mattresses or other equipment to protect the projecting shaft and hub of the needle. The method appears to have interesting future possibilities.

### CAUDAL SACRAL BLOCK

Block of the sacral nerves, either by a caudal, transsacral or high caudal block, or combinations of them, has been an outstanding method of anesthesia for various types of perineal operations. In general, the method causes very few complications or untoward effects provided it is employed by an experienced anesthetist. Routine caudal or caudal transsacral block provides anesthesia of most of the perineal structures and has a wide margin of safety, even in cases in which the surgical risk is very poor. The resulting anesthesia permits operations on the anus and lower part of the rectum, penis, prostate gland, bladder, perineum, vulva, vagina and uterine cervix. In many cases these operations can be performed by using 30 to 40 c.c. of a 1.5 per cent solution of metycaine as a caudal injection. In some cases anesthesia is incomplete and an additional block of the second, third and fourth sacral nerves on both sides is required. Occasionally, the first sacral nerves must be blocked. When this is necessary, a 1 per cent solution of metycaine is used throughout the operation. The resulting anesthesia and relaxation are profound and when epinephrine is used in



the anesthetic solution anesthesia of two to three hours duration results. Its use is routine in all anal operations at the Clinic unless some infective process over the sacrum is present or if the operative procedure is brief, such as the incision of a rectal abscess or opening a thrombosed hemorrhoid.

In the male sacral block is suitable for most transurethral operations and carries an even wider margin of safety than low spinal anesthesia but it has two drawbacks. One of these is pain on overdistention of the bladder owing to insufficient height of anesthesia. The other is priapism, which occurs in some cases. Since low spinal anesthesia is generally satisfactory and acts more promptly, the use of sacral block is reserved for certain cases in which the surgical risk is poor and in which spinal anesthesia is contraindicated.

In the female, sacral block is satisfactory for operations about the vaginal orifice and lower part of the vagina but the resulting anesthesia may be inadequate for vaginal hysterectomy, which involves the peritoneum. However, sufficient anesthesia for this type of procedure may be obtained by performing a high caudal block and injecting 40 to 80 c.c. of a 1 per cent solution of metycaïne into the caudal canal. This method actually is peridural anesthesia and the height of the anesthesia is governed roughly by the amount of solution injected. It is most important that the solution be injected very slowly, 10 c.c. at a time and that a few minutes be permitted to elapse between injections to permit distribution of the solution. Rapid injection may result in severe pain, a fall in blood pressure, syncope and other untoward effects. Precautions to prevent both intradural and intravenous injection must always be taken. Like peridural anesthesia, in general high caudal block for operations involving structures at a distance from the perineum may be incomplete in some cases, spotty in others and, with its slow onset is not 100 per cent satisfactory without supplementation.

#### CONTINUOUS CAUDAL ANESTHESIA

Since the use of single dose caudal anesthesia usually provides anesthesia of adequate duration, the use of continuous caudal anesthesia would seem to be superfluous in most cases in which caudal anesthesia is applicable. For certain long perineal operations its use might be considered. Either the needle technic or the ureteral catheter technic may be employed, depending on the position of the patient or the preference of the anesthetist. It is my feeling that the catheter technic permits more freedom in placing the patient in any desired position without danger of trauma from pressure on the needle.<sup>2</sup> A 1.5 per cent solution of metycaïne is employed with epinephrine, if the blood pressure is not grossly elevated. The initial dose ranges between 20 and 30 c.c. Additional doses of 10 c.c. are administered at suitable intervals as required.

## INTRAVENOUS ANESTHESIA

The intravenous injection of a solution of pentothal sodium to produce anesthesia has been found most applicable for many types of perineal operations.<sup>1</sup> Its chief drawback is the lack of profound muscular relaxation with moderate doses of pentothal sodium. Thus, however, is not a great drawback in operations on the perineum since this type of relaxation is seldom required or warranted. One of the exceptions is operations on the anus, as for hemorrhoids, fistulas, fissures and so forth. Relaxation is essential to the success of these operations and even deep pentothal anesthesia will not produce satisfactory relaxation in many cases. In addition, many surgeons prefer to operate with the patients in the prone position. Twisting of the patient's neck often results in serious difficulties in the airway. Thus, the advantages of intravenous anesthesia are lost. Short operations for acute inflammatory processes may be carried out under pentothal anesthesia and it is probably the method of choice for such operations. The necessary dose is small, and the patient usually is awake at the end of the procedure.

This type of anesthesia has been especially satisfactory for gynecologic operations by the perineal approach and its use for such procedures as dilatation and curettage, perineorrhaphy, operations for urinary incontinence and so forth has become almost routine in many institutions. Vaginal hysterectomy may be satisfactorily performed although the depth of anesthesia must be necessarily greater to provide relaxation for closure of the peritoneum. As previously stated, intratracheal anesthesia provides better control for long and difficult operations, such as the repair of a long-standing vesicovaginal fistula.

Its uses in transurethral prostatic resection are too numerous to mention and the method has proved to be a decided advance in this operation. The fact that pentothal sodium is well tolerated by the aged or toxemic patients, if it is administered with due regard to their physical state, has been a most desirable feature. Its effects on the function of kidneys that are grossly pathologic need not give rise to concern provided depressing doses are not administered. The same applies to a patient with marked chemical alterations of the blood. Patients with advanced cardiovascular renal disease may not be poor risks for intravenous anesthesia provided their myocardium is not sufficiently affected by the disease process to have produced dyspnea. If dyspnea of cardiac origin is present, these patients are poor risks for anesthesia with pentothal and this constitutes a contraindication. But, by and large, the fact that the elderly group of prostatic patients who obviously are poor surgical risks tolerate pentothal sodium well is evidence of its safety, when properly used. It is important to re-emphasize here, as I frequently have done previously, that these patients who are poor surgical risks (including patients in shock) comprise a vastly different problem for intravenous anesthesia than do

patients whose physical state is more normal. The former group of patients have reduced tolerance to the action of pentothal sodium. As such, they are affected by very small doses and pentothal sodium must be administered slowly and in very small divided doses, and particular attention must be paid to the airway, oxygenation and respiratory exchange.

At the Clinic, we generally use intravenous anesthesia for cystoscopy, ureteral catheterization, fulguration of vesical tumors, transurethral resection of small amounts of the prostate gland and for many types of plastic operations on the penis and scrotum. For resection of a large portion of the prostate gland, particularly in young men, low spinal anesthesia is preferred, since this group of patients require larger doses of pentothal sodium and have a tendency to strain if the anesthesia is light. Similarly, the degree of relaxation which spinal anesthesia provides for the manipulation and removal of ureteral stones may make this type of anesthesia preferable to intravenous anesthesia for this purpose.

#### COMBINED METHODS

Since the use of intravenous anesthesia has become widespread, the value of combined methods has become more apparent. This has been, to a great extent, due to the adaptability of intravenous anesthesia as a part of such combinations. Intravenous anesthesia itself is now combined almost routinely with the administration of oxygen or oxygen and nitrous oxide by inhalation. When used as a supplementary method, intravenous anesthesia now has a wide field since it may be administered very quickly. It frequently is used as an accessory method for perineal operations.

It is often employed to supplement topical or instillation methods if the patient has too much discomfort or pain during cystoscopy. Similarly, it is useful in supplementing various types of local and regional anesthesia. With spinal anesthesia it is used in small subanesthetic doses to control nausea, to relieve apprehension of a nervous patient or to produce additional anesthesia for prolonged operations. Only very small doses are required under these circumstances and, if the amount of pentothal sodium is kept minimal, the patient can be aroused before leaving the operating room.

In addition to these combinations there remains the combination of intravenous-intratracheal-nitrous oxide-oxygen with or without local anesthetic—a combination of anesthetic agents, free of the hazard of fire and explosion, with the assurance of a continuously free airway. This combination is flexible, safe and controllable.

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## CLINICS ON OTHER SUBJECTS

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### POSTOPERATIVE PULMONARY COMPLICATIONS

WILLIAM S. TINNEY

*If a patient has a fever elevated pulse rate or elevation of the leukocyte count or just does not do well after an operation and the difficulty cannot be readily explained by an obvious complication at the site of operation it has become customary to suspect a pulmonary lesion. In many instances this suspicion will be verified since pulmonary lesions are among the commonest of postoperative complications. It has been Lemon's<sup>6</sup> experience that in approximately one of fifty cases in which operation is performed some type of pulmonary disease develops and in one of 200 cases in which operation is performed pulmonary disease is directly responsible for death. Early diagnosis of these complications is essential because immediate treatment may prevent many days of hospitalization and may save the patient's life.*

Occasionally the attending physician focuses his attention so intently on the thorax that he overlooks a lesion elsewhere that is the primary source of difficulty. For example in many cases peritonitis is complicated by bronchopneumonia. The physician's interest may be so absorbed by the bronchopneumonia that the more important intra-abdominal lesion is neglected. Frequently a roentgenogram of the thorax following an abdominal operation reveals elevation of either side of the diaphragm and it is assumed that the cause of the elevated temperature or leukocyte count is a pulmonary lesion. It should be remembered that elevation of either side of the diaphragm occurs almost routinely after certain operations particularly cholecystectomy and splenectomy. The febrile reaction which often occurs during the first to fourth day following abdominal operations may also be misleading.

#### REPAIR OF VENTRAL HERNIA

Repair of large ventral hernias is occasionally followed by marked dyspnea and orthopnea because of the sudden increase of intra-abdominal pressure and consequent elevation of the diaphragm. Many of the patients are obese and respiratory distress is therefore more likely to develop than when the patient is not obese. Unless repair of such hernias is an emergency procedure these patients should be placed on a weight reduction regimen before surgical treatment is attempted. Fortunately serious pulmonary complications are not com-

mon but the patient is frequently very uncomfortable until he is able to sit up. Much of this discomfort can be alleviated by administration of oxygen.

### RESPIRATORY FAILURE

Occasionally, after operations on elderly patients, the respiratory rate falls to six or eight a minute. This is usually caused by the combined effect of preoperative sedation and prolonged anesthesia. When respiratory failure occurs, all postoperative sedation, particularly opiates, should be discontinued. Administration of 5 per cent carbon dioxide and 95 per cent oxygen is sufficient stimulant in most cases. Sometimes it is necessary to administer oxygen under positive pressure or to place the patient in a respirator.

### PNEUMOTHORAX

During operations on the upper part of the abdomen the incision may accidentally be extended above the diaphragm, or the diaphragm itself may be injured sufficiently to allow air to enter the pleural space and give rise to pneumothorax. This occurs occasionally during operations on the gallbladder. It happens most frequently during operations on the kidney. Pneumothorax occurs fairly frequently during thyroidectomy when it is necessary to explore the mediastinum for a substernal thyroid. Since the opening into the pleural space is usually closed without difficulty, pneumothorax is rarely a serious complication. Aspiration of air is unnecessary in most cases. Sometimes spontaneous pneumothorax occurs postoperatively and has no relation to the operative procedure. Diagnosis of spontaneous pneumothorax under such circumstances may be very difficult because this condition is encountered so infrequently as a postoperative complication. If tension pneumothorax develops, the patient may suddenly become severely dyspneic and go into shock or coma for no demonstrable reason. A roentgenogram of the thorax is often necessary to enable one to establish a correct diagnosis. When the air is slowly aspirated the patient experiences almost immediate relief. The safest method of aspiration is to employ any one of the popular types of apparatus designed for administration of pneumothorax so that the positive pressure can be measured. This is a safeguard against removing air too rapidly. To prevent laceration of the lung it is wise to use a dull needle and to introduce it slowly.

### BRONCHOPNEUMONIA

Onset of bronchopneumonia may be insidious, frequently occurring in the first week and often immediately following the febrile reaction. It is usually preceded by bronchitis and is much commoner among heavy smokers and elderly patients than among others. In Lemon's experience it attacks men three times as often as it does women. Bron-

chopneumonia rarely of itself causes death but it is frequently found in the terminal stages of serious diseases, such as peritonitis. The infection usually is easy to control with sulfadiazine.

#### ASPIRATION BRONCHOPNEUMONIA OF GANGRENOUS TYPE

This is a grave complication usually caused by staphylococci, streptococci or fusiform bacilli. Fortunately, this type of pneumonia is rare. The parenchyma of the lung becomes honeycombed by multiple abscesses of variable size and the bronchi are destroyed. The disease runs a rapid course. The most characteristic symptom is the expectoration of a large amount of purulent sputum, which has a sweetish, offensive odor.

#### SUBPHRENIC ABSCESS

Fortunately, subphrenic abscess is not a common condition. It is a complication that may result from any inflammatory process in the abdomen or from any abdominal operation. The thoracic complications of subphrenic abscess constitute the greatest danger. The diaphragm acts as an efficient barrier to the extension of thoracic infection to the abdomen but because of the direction of the lymphatic circulation, inflammatory lesions in the subphrenic region have a tendency to extend through the diaphragm into the thorax. When thoracic complications occur, serious diagnostic errors are often made because the pulmonary symptoms may be so striking that the patient is thought to have primary intrathoracic disease. Fairly frequently the first important symptoms and signs of a subphrenic abscess are caused by the extension to the thorax. This is the reason that the diagnosis of a subdiaphragmatic abscess too often is made after pulmonary complications have occurred. The existence of a free pleural space determines whether bronchial fistula, empyema or pneumonitis develops after perforation of the diaphragm by a subdiaphragmatic abscess. If the visceral and diaphragmatic pleurae are adherent to the diaphragm, the abscess perforates directly into the lung and causes pneumonitis and eventually bronchial fistula. If the diaphragm is not adherent to the basal portion of the pleurae, perforation is followed by extensive empyema. The empyema may subsequently rupture into the bronchus.

Cogetti and <sup>18</sup> have reported data on eighty cases of subphrenic abscess. Thoracic complications were present in fifty-two cases (65 per cent) of our series. Bronchial fistula, evidenced by cough and expectoration of large quantities of pus, was present in thirty-two (40 per cent) of our cases. The seriousness of delayed diagnosis of subphrenic abscess and the development of pulmonary complications is shown by the fact that in this series the mortality rate in fifty-two cases in which thoracic complications were present was 44 per cent while the mortality rate in twenty-eight cases in which thoracic extension was not present was 32 per cent. The presence of a bronchial

fistula is also of significance prognostically, since of thirty-two patients who had fistula, sixteen (50 per cent) failed to survive. The mortality rate in forty-eight cases in which fistula was not present was 29 per cent.

Roentgenographic studies of the diaphragm with anteroposterior and lateral views taken while the patient is in the erect position are of great value in the diagnosis. In this manner the presence of a fluid level under the diaphragm was demonstrated in 25 per cent of our cases. Immobility and marked elevation of the diaphragm are significant. Only by early recognition and treatment of subphrenic abscess will the thoracic complications be prevented.

#### PULMONARY EDEMA

When operations are performed on patients who have serious disease of the cardiovascular system it is wise to be on the lookout for pulmonary edema. This is especially important when dealing with elderly patients who have hypertension or coronary heart disease, since many of these patients may be on the borderline of cardiac decompensation. Pulmonary edema may occur postoperatively among patients who have impairment of kidney function and among those who have undergone extensive operations on the genito-urinary system. The commonest cause of postoperative pulmonary edema is the parenteral administration of an excessive amount of fluid, particularly saline solutions. Occasionally, pulmonary edema is precipitated by the administration of too much blood.

The diagnosis of pulmonary edema may be difficult. It is important to recognize this complication early so that parenteral administration of fluid can be stopped immediately. If the edema is severe it may be necessary to perform emergency venesection. Such radical treatment is usually not necessary. If possible, these patients should be placed in an upright position. The intravenous administration of diuretics such as aminophylline and mersalyl (salyrgan) is one of the most valuable procedures. Digitalis is often helpful. If the edema is resistant to the usual measures, it may be necessary to administer oxygen under positive pressure. This procedure should be used carefully in dealing with patients who are suffering from serious heart disease.

A complete record of the fluid intake and output during the postoperative period in all cases is the best means of obviating pulmonary edema. In general it is better to err on the side of too little rather than too much parenterally administered fluid.

#### ATELECTASIS

Atelectasis is the most common pulmonary complication after abdominal operations. Schmidt, Mousel and Harrington<sup>7</sup> have described its pathogenesis. The predisposing factors are (1) the type of opera-



tion performed (2) the position of the patient during the operation and (3) the effect of the anesthetic agent. The immediate causative factors are decreased pulmonary ventilation and inadequate endobronchial drainage. During operations on the upper part of the abdomen in which the patient is under general anesthesia, there are several important features which tend to produce postoperative atelectasis. Abolition of the laryngeal reflex makes it possible for infected secretions from the nasopharynx to be aspirated into the trachea and bronchi. The course of the right main and lower lobe bronchi is more direct than that of the bronchi on the left side. The infected secretions usually accumulate on the right side and are not expectorated because ciliary action is inhibited and the cough reflex is abolished. Retraction upward on either side of the abdomen compresses the diaphragm and the lower lobes of the lungs. After the operation the effectiveness of the cough reflex is reduced by the abdominal incision.

During operations on the kidney, the patient lies on the side opposite the site of operation. Secretions gravitate into the lower lung which is splinted by the weight of the body. Consequently, when atelectasis occurs after renal operations, it almost always involves the dependent portion of the lung on the side opposite the site of operation.

A number of measures can be taken to prevent atelectasis. It is dangerous to perform operation during or immediately after an acute respiratory infection. All elective procedures should be postponed until the patient has been free of symptoms for about two weeks. If the patient has bronchiectasis, chronic bronchitis or asthmatic bronchitis, it is advisable to delay elective surgical treatment until bronchial drainage can be established. It is often advisable in such cases to operate later in the day after postural drainage or bronchoscopic aspiration has been instituted. Bronchoscopic aspiration should be performed immediately after operation in cases of bronchiectasis.

Prolonged anesthesia should be avoided. Abnormal secretions should be removed promptly from the nasopharynx, hypopharynx and tracheobronchial tree. This is particularly important in cases in which lobectomy or pneumonectomy is performed. Immediately after an operation the patient should be turned frequently and encouraged to breathe deeply. Inhalation of a mixture of 5 per cent carbon dioxide and 95 per cent oxygen at regular intervals stimulates deep breathing. During the postoperative stage large doses of narcotics and sedatives should be avoided. Abdominal binders should not be applied so high that they impair the respiratory excursions. The patient should be encouraged to cough up any secretion that accumulates in the trachea and bronchi. Supporting the abdominal wall while the patient coughs decreases the pain and increases the effectiveness of the cough. Bronchial secretions can usually be raised by coughing. Deep breathing exercises and hyperventilation with carbon dioxide and oxygen are

sufficient in most cases. If these measures are not successful bronchial catheterization or bronchoscopic aspiration may be necessary. These procedures should not be delayed since the earlier atelectasis is diagnosed and treated the less chance there is of secondary pneumonia developing. In most cases postoperative pneumonia is secondary to atelectasis and could have been prevented if the atelectasis had been treated earlier. The results of early treatment of atelectasis are often dramatic. There is a rapid fall of temperature, pulse rate and respiratory rate when proper drainage has been established. Chemotherapy should be given if pneumonia develops.

#### PULMONARY EMBOLISM

One of the most important and frequent postoperative complications is pulmonary embolism. The sudden occurrence of a fatal pulmonary embolism is one of the great tragedies of medicine. For every fatal seizure there are usually two or three nonfatal attacks. De Takats and Jesser<sup>3</sup> have observed that those patients who survive one attack have a 40 per cent chance for another and that those who survive the second have a 12 per cent chance for a third attack. Vines<sup>4</sup> found that infarcts were multiple in 58 per cent of 125 cases in which pulmonary infarction was proved by necropsy. Barker, Nygaard, Walters and Priestley<sup>5</sup> reviewed a series of 172,828 operations performed at the Clinic and found that fatal pulmonary embolism occurred in 0.20 per cent of all cases. The type of operation had much to do with the incidence of pulmonary embolus. Only 0.01 per cent of those patients on whom thyroidectomy was performed had a pulmonary embolus but this complication occurred in 0.77 per cent of those cases in which splenectomy was performed. Pulmonary embolism was more common after operations of long duration and of great magnitude than after other operations. The incidence was high after operations on the female pelvic organs in which there was injury to or ligation of branches of the iliac veins. Operations in which considerable tissue was removed or injured and operations for carcinoma were likely to be followed by pulmonary emboli. The incidence of thrombosis and embolus was greater in cases in which fever and infection were present than in other cases. Pulmonary embolism occurred twice as often after appendectomy for ruptured appendix as after appendectomy for chronic or subacute appendicitis.

Cardiac disease is an important predisposing factor to pulmonary embolism. White<sup>6</sup> has found that this complication is most likely to occur in cases of congestive failure, of rheumatic heart disease, particularly mitral stenosis with atricular fibrillation and of coronary heart disease with myocardial infarction.

Many other important disturbances in the circulation which may lead to the formation of thrombi and resultant pulmonary embolism. The blood pressure is likely to fall after operation espe-

cially if the heart is damaged. Movements of the legs are limited and respiration is usually shallow. In many cases the velocity of the venous return is reduced after operations. A rise in the platelet count has been demonstrated postoperatively.

The importance of age as a predisposing factor has been stressed by many writers. In Vines's series 83 per cent of the patients were more than forty years of age. Pulmonary embolism is commoner among women than among men and the incidence is much higher among obese patients than among others.

If the accuracy of physicians in the diagnosis of pulmonary embolism and pulmonary infarction is to be increased they should not depend on the so called classic picture of cyanosis, dyspnea, pain, hemoptysis and friction rub. Unless there is obstruction to the venous return from the lung in cases of pulmonary embolism pulmonary infarction will not occur. This may explain the absence of clinical findings in many cases. In 15 per cent of Vines's series of cases of pulmonary infarction no clinical findings were manifest. The term silent pulmonary infarction has been given to this group. Pain was a symptom in only 32 per cent of Vines's series. Hemoptysis occurred in 18 per cent. A friction rub was heard in 11 per cent. When the cardinal signs are present it is often twenty-four hours after the onset.

White<sup>11</sup> and Barnes have described the cardiac phenomena which occur in cases of massive embolism. These have been attributed to acute dilatation of the right ventricle and pulmonary cone. Increased pulsation, loud systolic murmur, accentuation of the second pulmonic sound and friction rub may be noted in the second and third inter-spaces to the left of the sternum. Dilatation and pulsation of the veins of the neck are often observed. Cyanosis may be marked. Gallop rhythm is sometimes heard.

Although acute pulmonary embolism and acute coronary thrombosis have many symptoms in common the pain of coronary thrombosis is usually substernal and is more severe and prolonged than that of pulmonary embolism. The pain of pulmonary embolism is more likely to be in the lateral portions of the thorax and may be influenced by respiration. Severe dyspnea and cyanosis are more often observed in cases of pulmonary embolism than in cases of coronary thrombosis. There are electrocardiographic changes in many cases of acute pulmonary embolism which are valuable in its differentiation from acute coronary thrombosis.

**Prevention and Treatment.**—The most important consideration in treating a patient who has had a sublethal pulmonary embolus is the prevention of subsequent emboli. This can be accomplished most efficiently by proper use of dicumarol, a compound isolated from spoiled sweet clover and later synthesized. Barker, Allen and Waugh have given dicumarol to 497 surgical patients during their immediate postoperative convalescence. The dose for each patient was determined

on the basis of the effect on the percentage of prothrombin. The purpose of giving dicumarol is to keep this between 10 and 30 per cent of normal. If the percentage of prothrombin is kept below 30 per cent of normal, thrombosis almost certainly will not occur. If it is maintained above 10 per cent of normal, serious bleeding is unlikely to occur. Values for these prothrombin percentages should be determined by doing determinations of prothrombin time on 10 per cent, 20 per cent and 30 per cent normal plasma diluted with prothrombin-free plasma or 0.9 per cent sodium chloride solution. This should be done every time a new batch of thromboplastic substance is used for the prothrombin time tests, because these substances vary considerably in potency.

Dicumarol was given orally, 300 mg. the first day and 200 mg. the second day. Determinations of prothrombin time were performed daily, beginning on the third day. On each day that the percentage of prothrombin was greater than 20 per cent of normal, 200 mg. of dicumarol was given. The prothrombin time was allowed to return to normal after the patient became ambulatory, which was usually one or two weeks after operation. Barker, Allen and Waugh found that the increase of prothrombin time usually developed within twenty-four to seventy-two hours after the administration of dicumarol and that the effect persisted for from two to ten days after dicumarol was discontinued. When it was desirable to achieve a rapid elevation of the prothrombin time, 50 mg. of heparin was administered every four hours until the percentage of prothrombin was less than 20 per cent of normal. When it was necessary, because of hemorrhage, to control the prothrombin deficiency the patient was given a transfusion of freshly drawn blood and 60 mg. of menadione bisulfite intravenously. Excessive prothrombin deficiency in patients who were not bleeding was controlled by 60 mg. of menadione bisulfite alone. Thrombosis or embolism developed in only four cases and in three of these cases it occurred when the prothrombin time had dropped below the desired level.

Barker<sup>1</sup> has studied 180 cases of pulmonary embolism in which the patient was treated with dicumarol. None of these patients died of a subsequent embolism while the prothrombin deficiency was adequately maintained. Only one patient in this series died of a second pulmonary embolism and this occurred after the prothrombin time had returned to normal. It is interesting to compare this group with Barker's series of 678 cases of pulmonary embolism in which no anticoagulant substance was used. Eighteen per cent of the patients in the second series died of a subsequent pulmonary embolism.

The absolute contraindications to the use of dicumarol are: (1) renal insufficiency, (2) purpura, (3) blood dyscrasia with tendency to bleed, (4) existing prothrombin deficiency and (5) subacute bacterial endocarditis. Occasional bleeding was the only untoward effect asso-

ciated with the use of dicumarol. Bleeding was moderate to severe in eighteen cases or less than 4 per cent.

### SUMMARY

Pulmonary lesions are among the commonest of postoperative complications. Among valuable prophylactic measures is the use of dicumarol to prevent pulmonary embolism. Early diagnosis of pulmonary lesions is important because in many instances recovery of the patient depends on the promptness with which therapeutic measures are instituted.

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## RECONSTRUCTION OF THE COLUMELLA NASI. A METHOD ADVANTAGEOUS FOR THE FEMALE PATIENT

FRED Z. HAVENS

VARIOUS methods have been described for the reconstruction of the columella. Most of these are designed to make use of tissue from the upper lip. One method is to elevate a flap on the upper lip with its pedicle placed laterally and with its free end curving down toward the center of the vermillion border. The tip of this flap is brought up and sutured to the tip of the nose. After two to three weeks the pedicle is severed and sutured into the site of the base of the columella. The defect in the lip is closed by direct suture. Another method is similar except for the fact that the pedicle is at the philtrum and the tip of the flap is placed laterally.

By still another method a flap comprising the region of the philtrum is raised with its tip at the upper border of the lip and its pedicle at the vermillion border. The flexibility of the lip permits the tip of the pedicle to be attached to the tip of the nose as the first step. Later the pedicle is severed and transferred to the site of the base of the columella.

By another method two pedicle flaps are elevated, one on either side of the philtrum and parallel to it. The pedicles are at the base of the respective nasal alae and the tips are at the vermillion border. The two flaps are rotated medially and their tips attached to the tip of the nose.

Another method is to elevate a flap comprising the region of the philtrum by making two parallel incisions on either side extending from the floor of each nostril to the vermillion border. The flap thus elevated is lined first with a skin graft. After the graft has taken, the attachment at the vermillion border is severed and the lower end of the pedicle is brought up and attached to the tip of the nose.

By still another method a tubed flap is formed from the mucous membrane of the lining of the upper lip placed so that its base is immediately underneath the site of the base of the columella. Later the site of the base of the columella is opened and the prepared tubed flap is drawn through this opening and its tip sutured to the tip of the nose.

Still another method is to prepare a suitable tubed flap on the back of the hand or wrist. This later is transferred to the tip of the nose. The hand is held to the nose by suitable splints during the period necessary for the flap to become attached to the nose.

Each of these methods, except the one in which the mucous membrane is used and the one in which the skin of the hand is used, has



Fig 397—*a* and *b*, Preoperative appearance. The remnant of columella was too small to be of any value in the reconstruction.

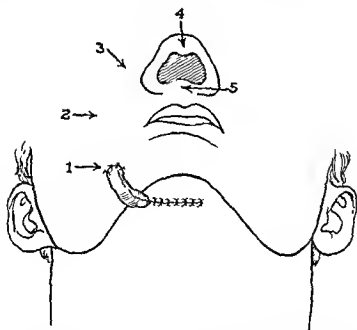


Fig 398—Drawing to show site of formation of tubed flap. The first transfer illustrated. Numbered arrows indicate sites of subsequent transfers.

the disadvantage of causing more or less noticeable scarring of the lip at the site where the flap was prepared.

Recently a female patient came under my care who had lost the columella (fig. 397, *a* and *b*) and who was especially anxious to avoid noticeable scarring incident to its reconstruction. A small tubed flap was prepared in the submental region. Six weeks later the distal end of the tube was disconnected and reattached at a point on the right side of the chin (fig. 398). Three weeks later the other end was transferred to a point just lateral to the angle of the mouth. By means of successive transfers at three-week intervals, the tube was "walked" up to its



Fig. 399.—*a* and *b*, Postoperative appearance. A cartilage implant has partially corrected the saddleback deformity. Insertion of additional cartilage was proposed but refused.

final position to restore the columella. A completely satisfactory columella was provided and the scarring at the points of successive attachment was quite inconspicuous (fig. 399, *a* and *b*). The operations for the successive transfers of the tube did not require hospitalization of the patient. She continued with her duties except for a couple of days at the time of each transfer.

In the case of a male patient the scarring incident to the use of a flap prepared from the upper lip, if noticeable, can be concealed by a mustache. In the case of the female patient the method described avoids the risk of noticeable scarring of the upper lip and in the one case in which I have used it the result was excellent.



## SURGERY OF THE SPLEEN

JOHN DEJ. PENIBERTON AND PAUL KIERNAN

THERE are today rather definite indications for the surgical procedure of splenectomy but its present status has been evolved mainly through clinical experience rather than through physiologic or pathologic knowledge of the spleen and its diseases, for we actually know little about the splenic functions and are not much aided by pathologic studies of this organ.

Table 1 shows the clinical diagnoses and the hospital mortality rate in cases which primary splenectomy was performed at the Mayo Clinic in the years 1904 to 1944, inclusive. Many conditions for which splenectomy was at one time performed are no longer considered surgical. Splenectomy, because of the low operative mortality rate and the good results obtained, seems definitely to be indicated following trauma of this organ with resultant massive hemorrhage, either primary or secondary, and in the treatment of hemolytic icterus, hemorrhagic purpura and splenic anemia, or Banti's disease.

Fairly frequently splenectomy is done because of interference with the blood supply of the spleen in other operations or as a secondary procedure to obtain easier exposure when removal of the organ is deemed necessary in operations on the stomach and pancreas and in the repair of diaphragmatic hernia.

An interesting indication for splenectomy recently has been advocated by Whipple<sup>12</sup> in the surgical treatment of portal obstruction with resultant ascites. In one case he reported good results following splenectomy and left nephrectomy with anastomosis established between the splenic and left renal veins, thus obtaining a direct and ample communication of the portal and caval systems and thereby relieving the load on the portal circulation.

Indirect or direct trauma to the spleen may result in fracture of the organ or tearing of the splenic pedicle, with resultant massive hemorrhage, either immediately evident or the more dangerous delayed secondary hemorrhage. If the hemorrhage is not controlled by nonsurgical measures, splenectomy should be advised, for other surgical procedures, such as attempt at suturing or picking, are rarely effective.

Injury to the spleen more often results in hemorrhage when the organ is enlarged as a result of disease, such as malaria or Gaucher's disease, than when it is of normal size. Grindley<sup>4</sup> reported a rather high incidence of splenic rupture in Chinese soldiers who have malarial splenomegaly, the injury usually having been sustained by direct trauma over the upper part of the abdomen.



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Splenectomy is usually not a difficult procedure. Its approach may be either abdominal or transthoracic, the former being more often employed. A left rectus muscle splitting incision affords good exposure. Some surgeons advocate preliminary ligation of the splenic artery at the superior border of the pancreas, along which this vessel courses, but we have not found this necessary. In cases of splenic anemia, because of the many dense vascular adhesions between the spleen and its

TABLE 1—CLINICAL DIAGNOSIS AND HOSPITAL MORTALITY RATE IN CASES IN WHICH PRIMARY SPLENECTOMY WAS PERFORMED IN THE YEARS 1904-1944, INCLUSIVE

Clinical Diagnosis	Patients	Hospital Deaths	
		Number	Per Cent
Splenic anemia	272	29	10.7
Hemolytic icterus	233	7	3.0
Hemorrhagic purpura	153	9	5.9
Pernicious anemia	62	4	6.5
Cirrhosis of liver	58	11	19.0
Myelogenous leukemia	46	3	6.5
Chronic infectious splenomegaly	40	10	25.0
Ruptured spleen	14	3	21.4
Syphilitic splenomegaly	13	1	7.7
Lymphocytic splenomegaly	13	0	0
Cancer's disease	11	3	27.3
Tuberculosis of spleen	10	1	10.0
Other conditions	78	13	16.7
Total	1093	94	9.4

parietal peritoneal bed, there may be much bleeding when the spleen is elevated into the incision. This can be well controlled by elevation of the spleen, quick packing of the splenic bed and careful individual ligation of the vessels of the splenic pedicle. Bleeding from the torn adhesions in the parietal peritoneum can be controlled after the spleen has been removed.

Aside from the disease for which splenectomy is undertaken, the operative difficulties, the condition of the patient as affected by asso-

ciated diseases and the like, there are two important factors which may influence the operative hazards, that is, the presence of hepatic impairment and the age of the patient. These should always be taken into account in any critical consideration of the operative risk.

Hepatic damage is a common finding in connection with splenomegaly. For the most part it is limited to association with splenic anemia or Banti's disease but occasionally it may be found in cases of hemolytic icterus of long standing. The severity of the damage varies usually in proportion to the duration of the disease and in our experience the degree of impairment, as determined by the bromsulfalein test, corresponds closely to anatomic changes as determined by gross and microscopic examination. All patients who are found to have moderate impairment of hepatic function should have preoperative treatment in an attempt to increase the reserve of glycogen. Patients who have severe impairment of hepatic function, especially if ascites is present, are always poor operative risks and medical measures offer insufficient prospect of improvement to warrant splenectomy, except at a tremendous hazard. However, from a limited experience with a few patients who had Banti's disease with ascites and definite functional impairment of the liver, encouraging results have been obtained in about 50 per cent of the cases by means of preliminary omentopexy. After an interval of three to six months these patients revealed marked general improvement in health and improvement in hepatic function as was evident from the result of the bromsulfalein test. At operation for removal of the spleen, the peritoneal cavity in all these cases was practically free of fluid and all of the patients readily survived the operation.

The age of the patient is an important and influential factor in the operative risk. Contrary to the opinion held by many, children and even infants endure splenectomy more easily than do adults of middle or advanced age. Our experience in the entire series of 1,003 cases in which splenectomy was performed shows that from the age of about forty years the hospital mortality rate rises continuously as the age increases (table 2).

There should be mentioned in this connection another hazard fairly common in operations on the spleen, that is, the development of postoperative portal or mesenteric thrombosis. In our experience, this complication has been limited for the most part, to cases of splenic anemia. Fourteen of the twenty nine hospital deaths in this group were caused by this complication. The increase in the number of platelets in the circulating blood that commonly follows the removal of the spleen undoubtedly plays an important role in this abnormal clotting of the blood but it is not the sole factor for in many cases the platelet count will rise to an abnormally high level without any apparent tendency to the development of thrombosis. Perhaps chronic endophlebitis of the splenic vein is the important contributing cause. The postoperative

administration of anticoagulants such as heparin and dicumarol, which are apparently playing a very important role in the prevention of fatal pulmonary emboli following all surgical procedures, is theoretically an excellent preventive measure in these cases but, owing to the relative infrequency of the complication and the danger of hemorrhage, these drugs should not be employed as a routine measure for all patients who undergo splenectomy.

In those cases in which the patient postoperatively demonstrates either so-called "silent" or inflammatory peripheral phlebitis, usually found present in the veins of the leg, or in which the patient shows evidence of endophlebitis of the splenic or mesenteric veins, one should

TABLE 2.—CASES IN WHICH PRIMARY SPLENECTOMY WAS PERFORMED  
1904-1944, INCLUSIVE.

HOSPITAL MORTALITY RATE, BY AGE

Age, years	Patients	Hospital Deaths	
		Number	Per Cent
0-9	91	4	4.4
10-19	146	8	5.5
20-29	220	17	7.7
30-39	221	16	7.2
40-49	177	22	12.4
50-59	115	20	17.4
60-69	31	6	19.4
70-79	2	1	50.0
Total	1,003	94	9.4

not hesitate to administer heparin intravenously in doses of 50 mg. every four hours and at the same time to begin administration of dicumarol by mouth. Usually 300 mg. of dicumarol is given the first day and 200 mg. the second day and the administration of heparin is stopped when the desired effect of the dicumarol has been reached, as determined by estimation of the prothrombin time (Quick's method). It is our custom to maintain the prothrombin deficiency at levels between 10 and 30 per cent of normal. This is easily accomplished and maintained by daily estimation of the prothrombin time and administration of dicumarol when needed.

It is of interest that in no surgical procedure at the Mayo Clinic in

which dicumarol has been administered and a satisfactory prothrombin deficiency maintained has there been a fatal pulmonary embolus.<sup>2</sup> One may easily control hemorrhage, which infrequently occurs following the judicious use of dicumarol, by transfusion of fresh citrated blood or the intravenous administration of large amounts (60 mg.) of menadione bisulfite (synthetic vitamin K).

Splenectomy, as previously stated, has been proved to be of definite value in the treatment of hemolytic icterus, hemorrhagic purpura and splenic anemia and the following discussion will be confined to a summary of our experience in this group of diseases.

#### HEMOLYTIC ICTERUS

The term "hemolytic icterus" is used as a diagnosis to include all cases in which there is increased hemolysis of red blood cells within the body, coincident with regeneration associated with variable jaundice and splenomegaly.

The characteristic blood picture is a form of anemia in which the erythrocytes are spheroid and microcytic and are more fragile to hypotonic saline solution than normal. They present a greater general diameter than do the normal biconcave red cells and, therefore, only with greater difficulty do they pass through the venous sinuses of the spleen. These cells do not appear in rouleaux formation, a fact which seems to make them more liable to hemolysis. The increased fragility is another factor which probably aids in their destruction. That this destruction of erythrocytes takes place in the spleen has not been conclusively proved but the fact that hemolysis ceases following splenectomy, although the cell characteristics remain unchanged, is good evidence that the success of splenectomy depends on the removal of an organ which, because of its unique circulatory properties, is capable of destroying abnormal erythrocytes.

From June 30, 1911, to December 31, 1944, inclusive, splenectomy was performed in 233 cases in the Clinic in which the diagnosis of hemolytic icterus had been made. Seven of the patients died in the hospital, a mortality rate of 3 per cent.

Since removal of the spleen in cases of hemolytic icterus is attended by only a nominal risk, since the benefits are, for practical purposes, curative and since there is danger of possible complications incident to neglect, such as the development of recurrent crises, gallstones and hepatic injury, splenectomy is definitely the treatment of choice in all cases. In this series of 233 cases of hemolytic icterus the incidence of cholecystic disease was 71.2 per cent. When the patient is seen in the crisis of the disease, the abdominal pain, jaundice, and particularly the direct van den Bergh reaction, which was a fairly common finding in this series of cases, are likely to lead the examiner to conclude erroneously that the patient has obstructive jaundice. In only three of the cases in this series were gallstones found in the common bile duct.

When the patient who has hemolytic icterus is known to have gall stones also and when it is inadvisable to operate on both organs in the course of the same operation, operation on the spleen should take precedence over that on the gallbladder.

Benefits of splenectomy become apparent within a few days as evidenced by a rapid and progressive improvement of the anemia. There is a noticeable fading of the jaundice, beginning about the fifth postoperative day, and by the end of ten days to two weeks it has disappeared entirely. However, as previously stated, certain characteristic changes in the blood such as spheroid microcytosis and increased fragility of the erythrocytes, commonly persist throughout the life of the patient.

The late results are equally gratifying. Of 162 patients on whom operation was performed five or more years ago and who were traced 144 lived beyond the five year period, giving a five year survival rate of 89 per cent. The ten year survival rate was 81 per cent, the twenty year survival rate was 67 per cent.

#### HEMORRHAGIC PURPURA

Hemorrhagic purpura is a disease of unknown causation characterized by hemorrhage from the mucous membranes, petechiae, ecchymosis and anemia. Examination of the blood reveals a low platelet count, evidence of normal regeneration of the formed elements, normal coagulation time but delayed retractility of the clot, prolonged bleeding time and the absence of immature cells which are distinctive of leukemia. With these hematologic findings the diagnosis of the chronic form of hemorrhagic purpura of moderate severity usually can be made without difficulty. In the acute forms of the disease however, one must exercise great care in excluding other hemorrhagic diseases particularly aplastic anemia, acute leukemia, hemophilia and symptomatic forms of purpura. Examination of the cells of the bone marrow obtained by sternal aspiration is of great value not only in establishing the diagnosis but also in determining the prognosis. The presence of normal regenerative changes in the erythrocytes and particularly the presence of normal megakaryocytes indicate that the cause of the decrease in the platelet count lies outside the bone marrow and that in such instances splenectomy can be undertaken with the assurance that postoperatively there will be an adequate increase in the number of platelets. Conversely, if the bone marrow shows the absence of normal regenerative processes of erythrocytes or the presence of any immature leukocytes, splenectomy would be contraindicated.

Although the spleen frequently is not enlarged in this disease it has been regarded as a most important factor in its pathogenesis and the success of splenectomy seems to support this belief.

The indications for splenectomy in this disease are dependent on the stage as well as on the severity of the disease. In the chronic and



incipient forms of mild severity, splenectomy is not recommended until medical measures, such as removal of foci of infection, have proved inadequate. In cases of moderate severity, splenectomy should be considered not only as a means of immediately improving the health of the patient but also as a means of preventing a possible acute exacerbation of the disease, when the risk of operation becomes greatly increased. In the acute forms of the disease, splenectomy is indicated when the diagnosis is definitely established. Although the risk of operation increases in proportion to the severity of the disease and to the duration of the acute exacerbation, splenectomy is the most certain means of preventing death from loss of blood or from bleeding into some vital structure, such as the brain or meninges.

The immediate results of splenectomy are as dramatic as can be found in surgery. Profuse bleeding which is uncontrolled by all other measures, abruptly ceases with removal of the spleen and complete and, in most cases, permanent recovery follows.

From March 7, 1923, to December 31, 1944, inclusive, splenectomy was performed for hemorrhagic purpura in 153 cases with nine deaths a mortality rate of 5.9 per cent.

Late results have been as follows. Of eighty-two patients on whom operation was performed five or more years ago and who were traced seventy-one lived beyond the five year period, giving a five year survival rate of 86.6 per cent. The ten year survival rate was 79 per cent. Only two patients on whom operation was performed twenty years ago or more were traced. Both of these are now alive and well.

#### SPLENIC ANEMIA

Today, after much investigative work by various groups, we probably know less than Banti<sup>1</sup> thought he knew in 1883, when he first called attention to the syndrome and maintained that the hepatosplenomegaly was caused by some unknown toxic agent that affected first the spleen and later the liver. This rather paradoxical statement is due to the fact that with time a number of conditions associated with splenomegaly and gastro-intestinal bleeding, which were formerly grouped under the heading of splenic anemia are today classified under different headings because of the fact that the cause of splenomegaly in these conditions can now be established. These include syphilitic splenomegaly, chronic infectious splenomegaly, Gaucher's disease and certain types of leukemic splenomegaly. There remains, however, a relatively large group of cases characterized by anemia of a secondary type with leukopenia, progressive splenomegaly, tendency to gastro-intestinal hemorrhage, cirrhosis of the liver and ascites, in which the disease runs a chronic course and is of unknown cause. These cases therefore fit the designation of the clinical pathologic entity which we know as splenic anemia.

The spleen in this group often is enormously enlarged, sometimes

attaining the weight of 7,500 gm. Of the three groups here discussed the pathologic picture presented by the Banti spleen is most characteristic. The capsule is greatly thickened and adherent to the parietal peritoneal splenic bed by vascular fibrous adhesions. Fibrosis and hyperplasia are diffuse throughout the organ and there are enormous dilatation and engorgement of all the vascular channels. The splenic artery usually is tortuous and its enlargement is far out of proportion to that found in the splenomegaly of similar dimensions associated with other conditions. The splenic veins are distended and turgid and often show evidence of advanced endophlebitis. Hepatitis or cirrhosis of the liver may or may not be an associated finding. In this series of 272 cases, definite hepatic impairment was noted in about 60 per cent.

Knisely,<sup>5</sup> in the Hull laboratories of the University of Chicago, adopted the method used by McNee<sup>6</sup> in studying the mouse's spleen by the dissecting microscope and a very powerful light and concluded that the vascular system of the spleen in mammals studied is a closed one, small connecting channels linking the arterial and venous systems. Stimulated by this Mackenzie Whipple and Wintersteiner<sup>7</sup> at the Spleen Clinic in New York, repeated this work but concluded that the vascular system is an open one, the splenic pulp providing the only connection between the arterial and venous systems. It is in these splenic pulp spaces, in the opinion of the group at Presbyterian Hospital, that blood circulates and is stored for varying periods, coming into contact with phagocytic white blood cells and histiocytes. They expressed the belief that these venous sinuses play a tremendous role in the pathogenesis of the abnormal spleen and the clinical picture. In the opinion of Whipple and his co-workers<sup>10</sup> the splenomegaly in Banti's syndrome is the result of hypertension of the portal bed. According to them "The back pressure in the venous sinuses transmitted by hypertension in the veins causes the distention of the venous sinuses and narrowing of the pulp spaces. This makes it more difficult for the blood to pass from the arterial capillaries into the pulp spaces. This results in hemorrhages about the trabeculated arteries and at the periphery of the follicles, with a later development of nodular areas of fibrosis—the typical fibroadenoma described by Banti."

Thompson, Caughey, Whipple and Rousselot<sup>11</sup> of the same clinic studied the venous pressures of the splenic and peripheral veins simultaneously in cases of Banti's syndrome and a control group and found that in the cases of Banti's syndrome the pressure was two to five times as great in the splenic vein as in the peripheral veins. Cases of schistosomiasis were then studied because of the known obstructive factor; the results were the same. Rousselot and Thompson<sup>10</sup> tried experimentally to produce splenomegaly by constriction of the splenic vein but failed. Either splenic atrophy or collateral circulation developed in the dogs without an increase in size of the spleen. To simulate the lesion produced by schistosomiasis they then injected particles of silica

into the portal veins of dogs and in several of the animals, after two years, cirrhosis, hypertension of the splenic vein and splenomegaly developed

In 1940 Rousselot<sup>6</sup> summarized the opinion of the Spleen Clinic group when he said that they were firmly convinced that the etiology of Banti's syndrome might be entirely explained on a mechanical basis i.e., portal bed obstruction with an associated portal hypertension the site being intrahepatic or extrahepatic

One of us (Pemberton)<sup>8</sup> has repeatedly pointed out that the hypothesis of mechanical obstruction in the development of splenomegaly 'does not explain the cause of portal hypertension in those cases which are unassociated with cirrhosis of the liver and in which there is no demonstrable extrahepatic obstruction of the portal or splenic veins To assume that the obstruction may be present but not demonstrable at operation is not valid It is not justifiable to conclude that splenic or portal thrombosis found at necropsy after splenectomy was necessarily present before operation In our experience, thrombosis of the splenic and portal veins is fairly frequently a complication of splenectomy in cases of splenic anemia Thus, of the twenty nine patients who died in the hospital thrombosis of the portal vein or its tributaries was the cause of death in fourteen Of the 116 subsequent deaths this was the cause in ten cases The decreased pressure in the splenic vein and the rapid rise of the platelet level both incident to splenectomy, are factors especially favorable to thrombosis

Our clinical evidence seems to indicate that the enlargement of the spleen is primary and hepatic involvement secondary, the enormous enlargement of the splenic artery present in these cases demonstrating an increased inflow of blood to the organ and therefore active congestion The cause of this increased flow of blood to the spleen is not known The increase may represent a response to infection or hyperplasia or it may result from some derangement of the mechanism which controls the activity of the splenic vascular system

The rationale of splenectomy in these cases may be briefly stated The operation lightens the load that has been thrown on the liver by reducing by at least 20 per cent the volume of blood entering the portal circulation and removes possible toxic substances originating in the spleen It removes the splenic factor in destruction of blood and produces adhesions for the establishment of collateral circulation

Between December 31, 1918, and December 31, 1944, inclusive splenectomy was performed at the Clinic on 272 patients who had splenic anemia and Banti's syndrome, twenty-nine patients died in the hospital, a mortality rate of 10.7 per cent The effect of operation has been most gratifying even in many of the advanced cases in which hepatic damage was present There are a rapid improvement of the anemia and a rise of the leukocyte count, followed by a general improvement of the health of the patient, as well as an improvement of

the hepatic function in a large percentage of cases, is determined by the bromsulfalein test

Two complications are outstanding as the cause of death. Of the twenty-nine patients who died in the hospital following splenectomy, six died of hemorrhage and fourteen of thrombosis. The most discouraging note in the results of operation for splenic anemia is the failure of splenectomy to check the hemorrhagic tendency completely, thus, in this series of 272 patients who had splenic anemia, 108 (40 per cent) have had one or more incidents of hemorrhage after splenectomy. Of the 173 patients who had hemorrhage before operation, ninety-three (53.7 per cent) have had recurrent bleeding after operation, but of the ninety-nine patients who had no gross bleeding before operation only fifteen (15.2 per cent) had subsequent bleeding. Clinical evidence would seem to indicate that the removal of a large, actively congested spleen tends to check the progress of the syndrome and thus, when the operation is performed in the early stages in the absence of esophageal and gastric varices, bleeding does not occur subsequently because of the removal of the principal factor (actively congested spleen) in the production of portal hypertension, which in turn is the principal factor in the production of the varices.

The development of collateral circulation between the portal and caval systems, which reduces the pressure in the portal vein, may be aided surgically by scarification of the parietal peritoneum to promote its adhesions to the viscera and also by incorporation of a segment of omentum into the abdominal wall. Instead of including part of the omentum in the line of cleavage on closure of the wound, as is commonly done, a stronger closure will be obtained if the omentum is incorporated into the abdominal wall lateral to the incision through stab wounds made through the different layers in a stepladder or staggered manner as one of us (Pemberton) has suggested. We have had as yet no experience with the procedure advocated by Whipple previously referred to.

That esophageal varices already present may be effectively and safely obliterated by the injection of sclerosing solution was first demonstrated by Crafoord and Frenchner.<sup>3</sup> Therefore, because of the danger of postoperative hemorrhage the injection of one of the sclerosing solutions into the dilated esophageal veins would seem warranted as a secondary procedure to splenectomy in all cases of splenic anemia in which esophageal varices can be demonstrated.

Late results have been as follows. Of 208 patients on whom operation was performed five or more years ago and who were traced, 114 lived beyond the five year period, giving a five year survival rate of 54.8 per cent. The ten year survival rate was 42 per cent. The twenty year survival rate was 23 per cent.

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# SURGERY OF THE STOMACH AND DUODENUM

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In this consideration of surgery of the stomach and duodenum, I shall confine my remarks to those situations pertaining to benign ulcer of the duodenum, gastric ulcer and gastric carcinoma. Since this subject is large, as well as extremely important, and since the allotted space is limited, the consideration necessarily will be somewhat brief and perhaps inadequate. My purpose then shall be to make the subject matter as practical as possible and perhaps useful.

## DUODENAL ULCER

It is noteworthy that during the past few years the management of duodenal ulcer has become chiefly a medical problem. The patients treated surgically today are composed of that small group who have

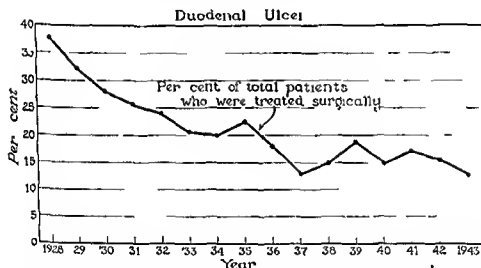


Fig. 400—Percentage of cases of duodenal ulcer in which surgical treatment was employed in the years 1928 to 1943 inclusive

intractable pain that do not respond to medical therapy and those who have repeated and massive hemorrhage, obstruction or perforation. This group now has been reduced to between 15 and 20 per cent of patients who have duodenal ulcer. Figure 400 shows the percentage of cases of duodenal ulcer in which operation was performed in the years 1928 to 1943 inclusive. Whether these figures can or should be reduced still further will depend on further improvement in medical therapy and careful selection of patients for surgical treatment, especially in cases in which there is any doubt regarding the advisability of operation. The latter is often a difficult problem especially if the

patients are young. Such patients are tense and dynamic, they frequently fail to adhere strictly to medical advice, and their symptoms may fluctuate markedly as a result of emotional disturbances. The decision as regards treatment is the joint responsibility of the diagnostician and the surgeon and should be based on mutual agreement.

Associated diseases often add risks which would cause surgical procedures to be inadvisable except in emergencies. The following case illustrates this point.

**CASE 1**—A man aged thirty years came to the Clinic in April 1942. His appendix had been removed at the age of sixteen years and his gallbladder had been removed at the age of twenty-two years. Both operations had been done to relieve indigestion but the patient had not been benefited. In August 1941 a gastroenterostomy had been performed and also had failed to produce any relief. He had gained 20 to 30 pounds (9.1 to 13.6 kg). In February, 1942, he had had an attack of abdominal pain, chills, fever and jaundice. These symptoms had disappeared for several days but they had recurred subsequently. The history certainly was suggestive of an old duodenal ulcer with obstruction which had been relieved by gastroenterostomy but the recent attack was suggestive of obstruction of the common bile duct by a stricture or stone. Roentgenologic examination of the stomach disclosed a gastrojejunal ulcer and an active duodenal ulcer. In view of the obstruction of the common bile duct an exploratory laparotomy was carried out on April 20, 1942.

An incision was made in the upper part of the right rectus muscle and all the old scars were removed. The common bile duct was exposed without much difficulty. It was opened and a considerable amount of good looking bile flowed from the opening in the common duct together with some flakes of bile pigment. The smallest scoop then met with resistance at the ampulla of Vater. A considerable amount of inspissated bile and sediment was removed from the ampulla. It was possible to get only a small probe through the ampulla into the duodenum but scoops could be passed into it. The duodenum was therefore, opened opposite the ampulla. The probe was going through the ampulla all right. Larger probes then were passed from the common bile duct through the ampulla. Some more sediment was removed. Examination with the finger inserted through the duodenal opening and into the pylorus revealed that the ulcer was situated on the mesial wall of the duodenum between the pylorus and the common bile duct close to the second portion of the duodenum. Part of the obstruction of the common bile duct apparently was due to the induration and inflammation caused by the ulcer. A retrograde curved forceps was passed through the ampulla of Vater without resistance and out through the opening in the common bile duct. As the patient had an active gastrojejunal ulcer as the gallbladder had been removed and as the ulcer in the duodenum encroached upon the common bile duct it was felt that the only possible solution was to insert a large T tube so that one branch of the T would come through the ampulla into the duodenum. The end of the T tube was inserted about  $\frac{3}{4}$  inch (1.9 cm) into the duodenum through the ampulla and bile flowed through it freely. In view of the patient's age it was felt that he should certainly be treated medically under close observation. There was considerable edema around the gastroenteric anastomosis. Both loops seemed to be free. If anything further should have been done it would have been necessary to disconnect the gastroenteric anastomosis and do a gastric resection. This I believe should not be done unless it is absolutely necessary. Five grams of sulfathiazole were placed around the closed incision in the duodenum and in the common bile duct and over the old gastroenteric anastomosis.

The convalescence was uneventful. The jaundice disappeared rapidly and the patient was sent home and advised to continue an ambulatory ulcer regimen. He has continued to improve under medical therapy.

It is significant, I think, that many patients with duodenal ulcer previously have undergone an appendectomy or cholecystectomy with out much benefit, which indicates the importance of a careful analysis of the symptoms in some cases of duodenal ulcer, especially when the patient is observed early in the course of the disease. Acute fulminating appendicitis or severe acute cholecystitis can hardly be confused with ulcer, but the ulcer may exist simultaneously with appendicitis or cholecystitis. A carefully taken history often will reveal that the ulcer symptoms were preceded for several months by mild symptoms which resemble those of appendicitis.

Gallstones that are associated with duodenal ulcer present a complication of considerable magnitude. Should one perform a cholecystectomy, do a gastric resection, do a gastro enterostomy or leave the ulcer entirely alone? First of all it must be clear that multiple simultaneous operations increase the surgical risk and the mortality, therefore, any additional gastric operation should be one of necessity. Under such circumstances, the primary surgical procedure would no doubt be for the duodenal ulcer and the gallstones more likely would be an incidental finding. However, given such a situation, a cholecystectomy is desirable and this might easily modify the surgical procedure for the duodenal ulcer, that is, a gastro enterostomy would be much safer than gastric resection although not as desirable physiologically. By and large, the method of procedure should be governed mostly by the judgment, skill and experience of the surgeon. With a surgeon of limited experience the safer operation should be performed although a more radical one may be indicated. Under subsequent medical care the patient may remain entirely free from symptoms after a conservative operation.

Gallstones may be associated with a duodenal ulcer of short duration and with mild symptoms. In most cases, it is best to remove the gall bladder and continue to treat the ulcer medically. One sometimes sees a case in which a duodenal ulcer will produce colic which simulates that of disease of the gallbladder owing to the ulcer being in close contact with the pyloric sphincter. The symptoms occur suddenly. They are severe and are associated with vomiting and abdominal soreness. At operation, the gallbladder is normal and does not contain stones. The ulcer may be, and usually is, indistinct and is situated on the mesial or posterior wall. For this reason the ulcer is sometimes overlooked or perhaps one should say that it is not identified. The patient does not obtain benefit from removal of the gallbladder since it is not involved in the pathologic process.

The identification of a duodenal ulcer at operation in the absence



of great deformity and edema or obstruction, is frequently such a problem that the surgeon may conclude that an ulcer is not present and close the abdomen. There are certain statistical data regarding duodenal ulcer that seem to me to be worthy of emphasis. In the first place, 71 per cent of all duodenal ulcers are situated on the posterior wall of the duodenum. If the anterior wall does not contain an ulcer, the only clue to the presence of an ulcer is fixation of the posterior wall, which varies considerably depending on the size and extent of the inflammation. This is especially so in the case of a hemorrhagic ulcer, which seems to be characterized by the absence of much inflammation of the contiguous tissues. Before concluding that an ulcer is not present, the surgeon should do one of two things. He should palpate through the gastrohepatic omentum and carefully examine the posterior wall of the duodenum adjacent to the pancreas for edema and for fixation to the pancreas. He also should search for inflammatory stippling of the tissues around the head of the pancreas. Should these maneuvers fail to disclose an ulcer, the duodenum should be opened by dividing the pylorus to permit accurate inspection of the duodenal and gastric sides of the pylorus.

An associated benign gastric lesion must constantly be kept in mind although it is not a particularly common finding. A duodenal ulcer may perforate onto the gastrohepatic ligament and retract the margin of the lesser curvature of the stomach in such a manner that the roentgenologist cannot say whether the ulcer is on the gastric side or duodenal side. This is sometimes very difficult to determine grossly or perhaps I should say anatomically. However, it is a dictum that a duodenal ulcer never passes over onto the gastric side and a gastric ulcer never passes over onto the duodenal side, but both a gastric and a duodenal ulcer can exist adjacent to the pylorus, which must be positively proved. A gastric resection is the operation of choice if both are present. This decision is easily made if the gastric ulcer is near the angle of the stomach since it is usually identified prior to operation. In cases in which both types of ulcer exist, the potentiality of recurring ulceration is too great to justify medical therapy. In such cases the ulcers should be considered definitely surgical.

When an acute perforation of a duodenal ulcer has occurred the surgical procedure to be done continues to be a very debatable one. Whether a partial gastrectomy or a closure of the perforation alone or combined with a gastroenterostomy is indicated depends in considerable measure, on the time that has elapsed between the perforation and the exploratory laparotomy. Within the first four hours after perforation the risk of gastric resection is no greater than that of gastroenterostomy but it does increase progressively from that point on. A patient may be seen at a time when only simple closure of the perforation is desirable. Not all acute perforations require surgical interference. If leakage into the general peritoneal cavity is not excessive

the perforation may be closed by the omentum and the under surface of the liver, provided that a Wangensteen suction apparatus adequately keeps the stomach and duodenum empty for forty eight to seventy-two hours. This procedure, of course, is preferable but not often possible. In the majority of cases in which perforation occurs the patients are beyond the fourth decade of life. Furthermore, the incidence of recurring ulceration and subsequent perforation or gastrojejunal ulceration after gastro enterostomy in this particular group of cases is such that, in my judgment, gastric resection is the operation of choice.

The surgical treatment of duodenal ulcer should have four main principles (1) the relief of symptoms (2) protection against complications, (3) protection against recurrence and (4) increase of life expectancy. The surgical measure which will fulfill these requirements

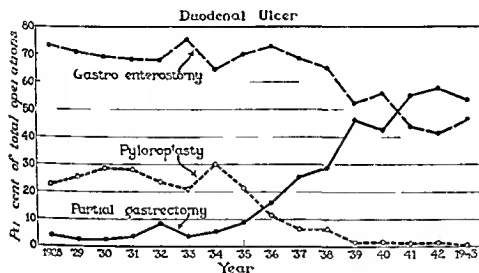


Fig 401—Incidence of gastro-enterostomy, pyloroplasty and partial gastrectomy for duodenal ulcer in the years 1928 to 1943 inclusive

has been the subject of much discussion. I am certain that more patients with duodenal ulcer should be treated by partial gastrectomy than was thought to be necessary a few years ago. I am equally certain, however, that it should not be a routine procedure in all cases regardless of the age and race of the patient and regardless of associated pathologic or debilitating conditions. The purpose of partial gastrectomy is to remove that portion of the stomach which is the most frequent site of ulceration and to produce a permanent reduction of the acidity of the gastric contents or a complete absence of free hydrochloric acid. The amount of the stomach which should be removed to accomplish this certainly varies in different cases. Most authors agree that it should never be less than 50 per cent and perhaps not more than 80 per cent. Total gastrectomy has been employed by some surgeons but I can not feel that such a radical procedure is ever indicated in

benign ulceration either duodenal or gastric. It is true that there is an occasional case in which the jejunum will not tolerate the gastric contents being passed directly into it without producing a jejunitis or a gastrojejunal ulcer. In these cases it is necessary to remove the remaining portion of the stomach or re-establish the gastroduodenal continuity. I shall consider this further under surgical procedures.

The changing character of the surgical procedures for duodenal ulcer at the Clinic from 1928 through 1943 is shown in figure 401. In 1941 partial gastrectomy was performed in more cases than was gastroenterostomy, and since that period the incidence of the two operations has varied only slightly. In 1943, the two operations were performed about an equal number of times. Most of the patients who formerly would have been treated by pyloroplasty now receive medical treatment. Fundamentally, this procedure failed to alter the acidity of the gastric contents, which is now known to be an essential requirement of the four principles of surgical treatment. The fact that partial gastrectomy and gastroenterostomy each were employed alone in an approximately equal number of cases indicates that at the Clinic we do not as yet hold to the opinion that partial gastrectomy should be performed as a routine procedure in all cases of duodenal ulcer. Patients must be selected carefully for either operation.

#### GASTRIC ULCER

Gastric ulcer cannot be considered the same as duodenal ulcer for very definite reasons. A duodenal ulcer rarely ever becomes malignant and a primary carcinoma of the duodenum is seldom seen. The evidence that a gastric ulcer may become malignant is too great to be ignored. The ulcer

tion. Some gastric careful medical the clinically or roentgenologically, whether the ulcer is malignant accounts in part for the high percentage of patients who are treated surgically for this lesion. The percentage of patients who are operated on for gastric ulcer at the Clinic has varied between 40 and 60 in the past few years, but during 1943 this percentage rose to about 65 (fig 402). One can easily err in being too conservative in the management of gastric ulcer. I think it would be far safer to regard all gastric ulcers as malignant until it has been proved without doubt that they are benign. A great deal has been said and written about the value of the size of gastric ulcers in determining whether they are benign or malignant. Large ulcers are not always malignant, but if such ulcers are situated near the angle of the stomach or high on the posterior wall the chances of their being malignant are great. On the contrary, large ulcers which are situated on the posterior wall in the lower third of the stomach and have perforated onto the pancreas are usually benign. Such an ulcer came under my observation quite recently. The ulcer

was so large and the crater so broad and deep that I felt certain it was malignant. The point of extreme importance was that if it had been malignant it would have been inoperable on account of the extensive involvement of the pancreas. If it was benign then resection was possible. To prove this point, I opened the stomach and took sections from various parts of the ulcer for immediate pathologic examination. None of the sections showed any evidence of malignancy. Grossly the ulcer appeared and felt like a carcinoma. A partial gastrectomy was performed and microscopic examination revealed that the ulcer was entirely benign. In such a case, it would be very easy and unfortunate to decide that the lesion was an inoperable carcinoma. The same type of lesion may occur high on the lesser curvature or in the cardia, but this is not likely.

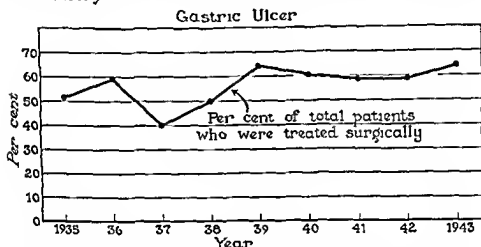


Fig. 40.—Percentage of cases of gastric ulcer in which surgical treatment was employed in the years 1935 to 1943 inclusive.

Gastric ulcer is often of short duration and the patients are somewhat older than those who have duodenal ulcer. In cases in which operation is not performed immediately, the patients should be treated in the hospital for two to three weeks. This procedure usually is employed in cases in which the history indicates that the ulcer has been present for a short time. If medical treatment causes the ulcer to become smaller and to disappear as determined roentgenologically and by gastroscopic examination, and if it causes occult blood to disappear from the stools, the treatment should be continued. The stomach should be examined roentgenologically every three months for one year or oftener if symptoms return. When this type of response is not obtained by medical treatment, patients should be advised to undergo surgical treatment at once.

#### CARCINOMA OF THE STOMACH

Carcinoma of the stomach has the same serious aspects as does carcinoma anywhere else, namely the lesion may be a silent one until it

reaches an inoperable state. Fortunately, more and more people are becoming cancer conscious and seek examinations earlier than they did formerly, however, very few people seem to think two months is a very long time, but in cases of carcinoma of the stomach it is a long time. It is sad but true that although some very intelligent patients consult their physician within two weeks after the first appearance of gastric symptoms examination discloses that they have an inoperable carcinoma. In some cases, carcinoma of the stomach may be inoperable when it first produces symptoms. It, therefore, would seem advisable for patients who have reached the so called cancer age to have periodic examinations of the stomach and of the stools regardless of whether symptoms are present or not.

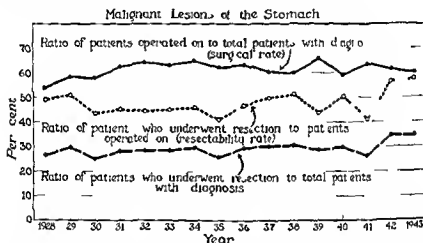


Fig. 403—Surgical rate, resectability rate and ratio of patients who underwent resection for malignant lesions of the stomach in the years 1928 to 1943 inclusive.

Figure 403 shows the surgical rate\* and the resectability rate† in cases of malignant lesions of the stomach that were observed at the Clinic in years 1928 to 1943 inclusive. This shows that the surgical rate and the resectability rate have increased in these years. The increase in the surgical rate perhaps can be attributed to the fact that patients who have a malignant lesion of the stomach now are consulting a physician somewhat earlier in the course of the disease than they did previously. As a result, the patients now are in better physical condition when they first consult a physician. Physical and roentgenologic examination will not always disclose whether the lesion is re-

\* The surgical rate is the ratio, expressed in per cent, of the number of patients on whom operation was performed to the total number of patients having the diagnosis.

† The resectability rate is the ratio, expressed in per cent, of the number of patients on whom resection was performed to the total number of patients on whom operation was performed.

sectable. If there is any doubt about the resectability of the lesion an exploratory laparotomy should be performed if the patient is not a poor surgical risk. In many cases in which the clinical and roentgenologic findings indicate that the lesion is not resectable, an exploratory operation will indicate otherwise.

If there is no evidence of extensive involvement of the regional lymph nodes when the abdomen is opened, there are certain signs that aid in determining the advisability of resection. If the cul de-sac contains more than the usual amount of fluid it is a very ominous sign. If there is considerable edema of the lesion and if the adjacent portions of the stomach are edematous, the prognosis is poor. This is an indication that the lesion is growing rapidly and that the regional lymphatics have been occluded by malignant cells. This also may be the case with the lymphatics at considerable distance from the lesion and involvement of the liver is most likely. The lesion may appear to be resectable but resection may be inadvisable owing to the debilitated condition of the patient. On the contrary, a lesion that is very large and firm and associated with large lymph nodes, and perhaps is attached to the transverse colon or mesocolon may, at first sight, appear to be inoperable but it may be possible to perform an extensive resection of the stomach, omentum and perhaps a segment of the transverse colon. Such a lesion is extending slowly regardless of the grade of malignancy. It usually has been present for a long time but the patient generally is in much better physical condition than the appearance of the lesion would indicate.

#### SURGICAL PROCEDURES

The surgical procedures most frequently employed in the treatment of duodenal ulcer, gastric ulcer and gastric carcinoma are as follows: gastro-enterostomy, an anterior or posterior Polya type of resection, a Billroth I, Shoemaker or Hoffmeister type of resection, and total gastrectomy. Some surgeons prefer one type of operation in preference to another, but I do not believe that one type of resection is applicable to all lesions. It would seem preferable to be familiar with most of the standard procedures and apply them where indicated.

If a posterior gastro-enteric anastomosis is to function well, it must be made at the dependent portion of the stomach, directly opposite the angle of the stomach. The stomach should be brought through the mesocolon to the left of the middle colic vessels so that there will be no interference with the drainage of either jejunal loop. The proper application of the jejunum to the stomach cannot be overestimated. A malfunctioning posterior gastro-enteric anastomosis frequently is observed in cases in which the operation was difficult to perform owing to a very fat mesocolon or a mesocolon that is unusually short. In cases in which this procedure is at all difficult to perform, it would be wiser to do an anterior gastro-enterostomy. There is no doubt that a

malfunctioning gastro-enteric stoma is liable to be followed by a gastrojejunal ulcer. However, this is not the only cause of a gastrojejunal ulcer. Figure 404 shows a gastrojejunal ulcer and the surgical procedures employed for the treatment of such an ulcer.

Gastrojejunal ulcer (fig. 404, *a*) is practically always a surgical lesion, especially if it causes considerable disability. The preferable operation to be done is to disconnect the jejunum from the stomach, excise the jejunal ulcer, and close the defect in the jejunum transversely, and perform a partial gastrectomy. Occasionally it is necessary to resect a

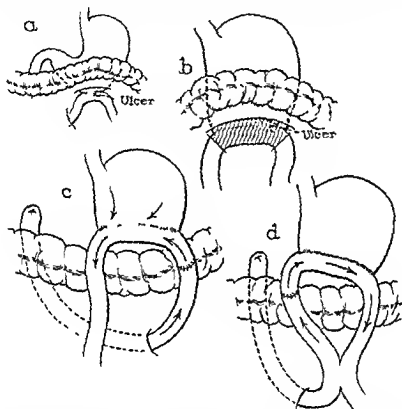


Fig. 404—*a*, Gastrojejunal ulcer, *b*, a long proximal loop will favor the development of a stomal ulcer *c*, Lahey's operation, *d*, Polya-Balfour operation

portion of the jejunum and do an end-to-end anastomosis. If the original operation was a posterior gastro-enterostomy, one should perform some type of anterior gastric resection, such as the anterior Polya-Balfour operation (fig. 404, *d*) and an entero-anastomosis, or the operation described by Lahey (fig. 404, *c*). In the operation described by Lahey, the proximal loop of the jejunum is applied to the greater curvature of the stomach. This loop should be long enough to permit the stomach to lie well to the left of the spinal column without tension on the jejunum. The Polya-Balfour type of resection produces a long

proximal loop to the lesser curvature, in contrast to the Lahey operation. An entero-anastomosis is made at the most dependent portion of the proximal loop to permit adequate drainage of this loop, because a long proximal loop without drainage does predispose to stomal ulcer (fig 404, *b*), usually within a few months. The rapidity with which a stomal ulcer may form if the pylorus is left intact is illustrated by the following case.

CASE 2—A married woman, fifty one years of age, came to the Clinic January 17, 1945, because of severe pain in the left breast and below the left ribs. The pain had been present since the previous July. In 1935, a gastro enterostomy had been performed for chronic duodenal ulcer. She had been well for four years, when ulcer symptoms had returned and another gastro enterostomy had been performed higher on the stomach. This operation had produced very little relief. In February of 1944, the abdomen again had been opened and adhesions had been separated. Pain had continued and in May, 1944, a partial gastrectomy had been performed. This resection had been of the anterior Polya type with a long proximal loop to the greater curvature. The pyloric end of the stomach had been left in place. The following July, which was only two months after her previous operation, the pain had returned, it had been equally as severe as it had been previously but it had been situated a little higher to the left. The pain had been constant and severe under the left breast and had extended to the left side. The pain had been relieved by the taking of food and milk and bicarbonate of soda. A diagnosis of gastrojejunal ulcer was made.

On January 29, 1945, operation revealed a huge gastrojejunal ulcer and an active chronic duodenal ulcer. It was noted that about 2 inches (5 cm) of the pyloric end of the stomach had been inverted and that the pylorus and duodenum had been left intact. There was a large gastrojejunal ulcer about the size of a silver dollar (3.8 cm) which had perforated onto the left abdominal wall. The gastro enteric anastomosis was then disconnected and about 4 to 5 inches (10.1 to 12.7 cm) of jejunum was resected and an end to end anastomosis made. The remaining portion of the pyloric end of the stomach with a portion of the duodenum including the duodenal ulcer, were excised and the duodenum was left open temporarily. A Shoemaker type of resection of the stomach was performed. Most of the lesser curvature and about 1½ inches (3.81 cm) more of the stomach were removed. The portion of the stomach corresponding to the lesser curvature was closed and the lower end of the stomach was anastomosed to the duodenum with three rows of sutures anteriorly and posteriorly. The stomach was then sutured to the suspensory ligament of the liver to relieve tension on the suture lines. There was a small leak at the suture line about the twelfth day but duodenal suction by means of a tube introduced through the nose kept the stomach empty and the opening was closed eight days later. Convalescence was otherwise uneventful and the patient was free of any distress.

This case also illustrates the advantage that may be gained by re-establishing gastroduodenal continuity. It also is fair to assume that the original operation perhaps should have been a Billroth I type of gastric resection.

A benign gastric ulcer that is situated on the lesser curvature near the esophagus presents a difficult surgical problem. A total abdominal gastric resection or a transthoracic partial resection of the cardiac portion of the stomach with reimplantation of the esophagus into the



stomach is inadvisable and too radical, I believe it is much safer and that physiologic processes are less disturbed if the type of resection illustrated in figure 405 is performed. The entire lesser curvature including the ulcer and the lower half of the stomach is resected. A small segment of stomach (fig. 405, *a*) is saved and anastomosed to the jejunum by a posterior or anterior Polya type of operation (fig. 405, *b*). It has proved to be very useful.

**Management of the Duodenal Stump**—The closure of the duodenal stump in gastric resection for gastric ulcer or carcinoma is not the problem that it is in resection for duodenal ulcer. Most deaths following gastric resection for duodenal ulcer are due to leakage at the stump, which produces generalized peritonitis. This difficulty arises from not having sufficient tissue to close the end of the duodenum adequately and without tension. The use of a crushing clamp on the duodenum in cases of duodenal ulcer is inadvisable since it usually

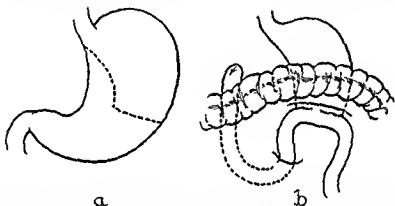


Fig. 405—Operation for benign ulcer situated high on the lesser curvature of the stomach. *a*, a small remaining portion of the stomach is anastomosed to the jejunum. *b*, anterior Polya type of resection.

destroys the only good tissue that is left to invaginate. A smooth curved clamp is preferable and is easier to remove. If the ulcer is situated on the posterior wall of the duodenum and involves the pancreas, a clamp of any type cannot be used. In this instance, the outer wall of the duodenum should be opened opposite the ulcer and the line of division extended around the duodenum to the ulcer. The ulcer can then be excised and a sufficient amount of duodenal wall can be cut loose from the pancreas to permit easy closure of the stump with two rows of catgut sutures and a protecting row of interrupted silk sutures which brings the capsule of the pancreas to the outer wall of the duodenum. A small Penrose drain placed under the gastrohepatic ligament seems to me to be very desirable. If the stump does leak it can be immediately discovered and suction applied if this drain is used. A small leak is of no consequence if suction is applied early. A subhepatic abscess or generalized peritonitis resulting from delayed drainage may be avoided.

## TOTAL GASTRECTOMY

JOHN M. WAUGH AND GEORGE T. R. FAHLUNO

FROM 1884, at which time Conner<sup>6</sup> performed the first total gastrectomy in man, up to the present day, total extirpation of the stomach has been accomplished successfully in a rapidly increasing number of cases. Conner's patient unfortunately expired on the table and it was not until thirteen years later that Schlatter<sup>20</sup> in 1897 accomplished the first successful total gastrectomy in man. His patient lived one year and fifty-three days, dying of a recurrence of the carcinoma.

The following year, 1898, an American surgeon, Brigham,<sup>2</sup> successfully performed total gastrectomy with esophagoduodenostomy, the first such operation performed on man. Prior to that time esophagojejunostomy was the method of anastomosis used.

From that period on there has been an ever-increasing literature on the subject up to the present time. This increasing interest has been noteworthy, particularly during the past ten or fifteen years. Prior to the report of Finney and Rienhoff<sup>8</sup> in 1929, the literature consisted almost entirely of isolated reports of successful cases. Occasionally, there would appear reports of two or three cases but no series of any great magnitude was written up. Finney and Rienhoff's contribution, then, marked a milestone in the progress of surgery for carcinoma involving the upper confines of the stomach and it undoubtedly served as a great impetus for further development of the surgical approach to this problem. They included a series of 122 cases which had been reported in the literature up to that time. Fifty-five of the patients, however, had a small portion of stomach left behind, although less than 3 cm in extent. Thus, Finney and Rienhoff considered only the remaining *sixty-seven cases as examples of true total gastrectomy*. The surgical mortality rate of these sixty-seven cases was 53.8 per cent. These investigators stated that the longest period of life following total gastrectomy was that in a case reported by Zikoff in 1911. His patient lived four years and eight months. Recent reports of patients living more than five years following total gastrectomy have appeared.<sup>18</sup>

Since 1929 there have been a number of reports of series of total gastrectomies done by various surgeons in the United States, Canada and abroad. Thus, Lahey and Marshall<sup>14</sup> reported a series of thirty-three cases, Graham,<sup>10</sup> twenty-one cases, Morton,<sup>16</sup> four cases, de Amesti,<sup>1</sup> nine cases, Walters, Gray and Priestley,<sup>25</sup> forty-three cases and Farris, Ransom and Collier,<sup>7</sup> twenty-nine cases.

Pack and McNeer,<sup>18</sup> in 1943, completed an excellent collective review of the literature on total gastrectomy for cancer and they included an original report of twenty cases of their own. For the total

of 303 cases reported, the operative mortality rate was 36.9 per cent, whereas the surgical mortality rate for the 298 cases of total gastrectomy for cancer was 37.6 per cent.

It was felt by us that the time is now at hand when a complete consecutive series of cases from a single surgical center would be of interest. Thus a surgical mortality rate obtained from such a relatively large number of cases would be more reliable than one taken from a collective review of the literature, which obviously does not include all of the cases in which the outcome is unfortunate.

In our series we began with the first total gastrectomy performed at the Clinic by Dr. W. J. Mayo in 1917 and reviewed every case up

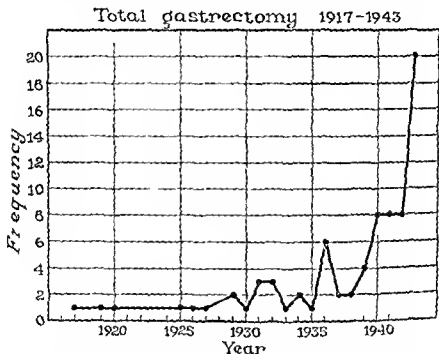


Fig. 406 Cases in which total gastrectomy was performed at the Clinic.

to and including 1943. Seventy-seven cases in all were found. Care was taken to include in this series only those cases in which the entire stomach from esophagus to duodenum was removed. Figure 406 demonstrates the increasing frequency with which this operation has been undertaken at the Clinic during the past four years (1940 to 1943 inclusive). In 1943 total gastrectomy was performed in twenty cases.

The over all hospital mortality rate for the group was 44.2 per cent. The hospital mortality rate for the forty-four cases in which operation was performed in 1940 to 1943 inclusive was only 31.8 per cent as compared with 60.6 per cent for the thirty-three cases in which operation was performed from 1917 to 1939 inclusive. In 1943, total

gastrectomy was performed on twenty patients. There were five deaths or a mortality rate of 25 per cent. This is a most encouraging improvement, one which might seem attributable to refinements in surgical technique, in anesthesia, in preoperative and postoperative care and to the use of chemotherapeutic sulfa compounds.

The age distribution of the seventy-seven patients ranged from thirty-one years to seventy-two years. In fact, two patients who were seventy-two years old survived the operation. One of these cases has been reported previously by Giffin and one of us (Vaughn)<sup>26</sup> in 1941. The average age for the entire group was 54.2 years.

Fifty-eight (75 per cent) of the total group were men and nineteen (25 per cent) were women. The operative mortality rate for men was 48.3 per cent as compared with 31.6 per cent for women. This would seem to indicate that women, by virtue of sex alone, tolerate the procedure of total gastrectomy better than men. This probably is related to the problem of the ease of exposure in accomplishing the resection and anastomosis because of the physical stature of the patient.

Walters<sup>23, 24</sup> has stated that the indications for total gastrectomy for carcinoma are as follows: (1) The lesion should be confined entirely to the stomach without evidence of distant metastasis, (2) the entire stomach and the lower end of the esophagus should be sufficiently mobile to enable the surgeon to remove the stomach and to make the esophagojejunal anastomosis without too much difficulty, and (3) the general condition of the patient should be good, so that the risk assumed is not too great.

There are a few other situations for which total gastrectomy was done in this series, namely, large gastric ulcers high in the cardia in contiguity with the cardiac orifice of the esophagus which were impossible to tell from malignant ulcers—five cases, lymphosarcoma involving the entire stomach or its upper portion, making it impossible to leave some of the cardia and still accomplish a wide enough removal—three cases, large sessile polyp occupying a large portion of the stomach with a broad base high on the cardia—one case, and one case with extensive polyadenomas en nappe de Menetrier and polypoidosis (Kirklin and Broders)<sup>12</sup>.

In addition to these cases mentioned, there were two cases in which total gastrectomy was done for palliative relief in the presence of demonstrable irremovable metastasis. It is, of course, open to debate whether palliation should be attempted in such cases, the answer depends on "the philosophic outlook of the surgeon" as expressed by Graham.<sup>11</sup> However, one patient lived four months in relative comfort and the other was still living at last report five months after operation and was in comfort.

In sixty-seven of the total of seventy-seven cases, gastrectomy was done for carcinoma. In the vast majority of cases, the carcinoma was grade 3 or 4 (Broders) and in 28.4 per cent of the carcinoma

group there was no involvement of lymph nodes. It is this last observation, frequently made for years past, which affords the real incentive for carrying out such a formidable procedure as total gastrectomy on these patients. A classification of the pathologic changes in these cases is given in table 1.

Patients who survived the operation and were dismissed from the hospital were carefully followed so far as possible. Thus, by follow up letters and by re-examination at the Clinic, information as to the subsequent course of the patient was obtained in all but eleven cases. From these data, together with information obtained from the hospital and

TABLE 1—SUMMARY OF PATHOLOGIC CHANGES IN 77 CASES OF TOTAL GASTRECTOMY

Pathologic Changes	Subgroups	Total Cases	Per Cent	
			Of Subgroups	Of 77 Cases
Malignant lesions				
Lymphosarcoma		3		4
Carcinoma	48	67	72	87
	19		28	
	7		10	
Grades 3 and 4	60		90	
Benign lesions		7		9
	1		14	
	2		29	
	3		43	
	1		14	
Total		77		100

Clinic records, a tabulation of the survival rates of those patients on whom total gastrectomy had been done for malignant lesions of the stomach was made and is herewith presented in table 2.\* The important fact revealed by such a tabulation is that more than half of the patients who survived total gastrectomy for carcinoma lived two or more years after operation.

In seven cases operation was performed for benign pathologic changes. Five patients survived operation and two of these have lived for more than eight years and six years respectively and are still alive at last report (February 1, 1944).

\* We wish to express our gratitude to Mr. Robert Gage of the Division of Biometry and Medical Statistics, Mayo Clinic, for his aid in the calculation of the survival rates presented in table 2 and also for his constructive suggestions wherever needed in dealing with the statistics presented in this paper.

Table 2 gives an estimate of the annual rate of survival for the thirty-eight patients who were dismissed from the hospital. Although the series is small, in a statistical sense, and the rates obtained cannot be considered entirely reliable, it was felt that from these calculations a general picture could be visualized of the future of these patients who survived total gastrectomy. For example, in the experience of this group one notes that about 50 per cent of the patients live more than two years following their operation. Also, the longest lived patient survived four years.

TABLE 2—TOTAL GASTRECTOMY FOR MALIGNANT LESIONS OF THE STOMACH 1917-1943, INCLUSIVE SURVIVAL RATES FOLLOWING DISMISSAL FROM HOSPITAL

Interval Following Hospital Dismissal Years	Last Report		Total Persons Living at Beginning of Interval	Person, Years Exposed	Probability of Dying in Interval	Survival Rate* Per Cent
	Dead	Living				
0-1	7	11†	38	32.5	0.2154	100
1-2	5	4	20	18	0.2778	78.5
2-3	6	2	11	10	0.6000	56.7
3-4		2	3	2		22.7
4-5	1		1	1	1.000	22.7
5-6						0

\* The calculated probability of living from the time of leaving the hospital to the beginning of the interval.

† These include those patients who were operated on during 1943 and not traced.

#### ANESTHESIA

The anesthetic agents employed in this series of cases varied but inhalation anesthesia of some type was used in every case. In a few instances, regional block with procaine hydrochloride was employed adjunctively. The anesthetic agents included ether, nitrous oxide, ethylene and cyclopropane. The McGill intratracheal tube was made use of frequently in cases in which it seemed needed in order to maintain an efficient airway. In no instance was spinal anesthesia used and our preference remains for intratracheally administered ether.

#### TECHNIC

Whenever it had been anticipated that total gastrectomy probably would be carried out, an upper left paramedian or upper midline incision was made. However, in eight cases it was accomplished through an upper right rectus incision. In one case an upper left transverse incision was used and in another a right rectus together with a transverse incision was utilized.

In no case in this series was it found necessary to divide the perit-

oneal reflection of the left lobe of the liver from the diaphragm in order to aid in the exposure as advocated first by Turner.<sup>22</sup>

The usual type of procedure consisted of the technic as outlined by Walters, Gray and Priestley.<sup>23</sup> There were a few variations in detail, as for example, in type of suture material used in making the anastomosis and so forth but the fundamentals for the most part were adhered to. In table 3 a summary of the procedures employed is given.

In two cases the method described by Graham<sup>10, 11</sup> was carried out. Of course, in this procedure an entero anastomosis becomes obligatory because in carrying out the technic the proximal jejunal loop is obstructed. Unfortunately in both cases in which the Graham technic was used the patient died. The first patient lived seven days, dying of bilateral bronchopneumonia following extensive atelectasis. Bronchoscopy was performed twice with only temporary benefit. Necropsy revealed an

TABLE 3—SURGICAL PROCEDURES IN 77 CASES

Type of Procedure	Number	Per Cent
Antecolic esophagojejunostomy	37	48
Postcolic esophagojejunostomy	35	45
	2	3
	2	3
	1	1
Total	77	100

excellent condition of the line of anastomosis and there was no indication of leakage. The second patient expired on the third postoperative day. Necropsy in this case revealed infarction of the jejunal portion of the anastomosis with resultant leakage and peritonitis. This patient had an extensive lymphosarcoma and it was necessary to resect the jejunum because of the presence of a gastro-enteric stoma. This probably caused the infarction.

Graham stated that in seven cases in which this technic was utilized, there was only one hospital death. Recently, it has been used by Sweet<sup>24</sup> in effecting esophagojejunostomy in three of seven cases in which transthoracic total gastrectomy was performed. In all three cases the result was successful without any evidence of leakage at the anastomosis. The procedure will require further use in order to compare it with the conventional end to side esophagojejunostomy which has been and is at the present time the favored technic at the Clinic.

Esophagoduodenostomy was done in two of the early cases in this series. Both of these patients died in the hospital, one on the thirty-fifth postoperative day, the other on the third postoperative day. In the first case, necropsy revealed local peritonitis, abscess and forma-

tion of fistula due to leakage at the anastomosis. The second patient died of a large intraperitoneal hemorrhage (2.5 liters of blood). Such an anastomosis is possible only in the rare situations in which the duodenum is unusually mobile and the abdominal portion of the esophagus is exceptionally long and placed low on the lesser curvature of the stomach. The duodenum is extensively mobilized by incising the peritoneum just beyond the lateral edge of the second portion of the duodenum. The duodenum is then freed by blunt dissection from its posterior attachments, a procedure which restores its embryologic position as a midline organ with a posterior mesentery, as described originally by Kocher<sup>13</sup> in 1902.

Pack and McNeer have pointed out that in the total group of reported cases of total gastrectomy those in which esophagoduodenostomy was done carried a mortality rate of 40.7 per cent as compared with 33.9 per cent in those in which esophagojejunostomy was done. Thus, together with the technical difficulties encountered in performing esophagoduodenostomy, has led them to abandon the procedure in favor of esophagojejunostomy.

In one of the early cases in this series anastomosis following total resection of the stomach could not be effected. Thereupon the end of the esophagus was tied off and dropped back, the duodenum was closed and jejunostomy was performed. The patient died on the fourth postoperative day and necropsy revealed beginning purulent posterior mediastinitis, early vegetative mitral endocarditis and bilateral bronchopneumonia.

Total gastrectomy has been accomplished through the transthoracic transdiaphragmatic approach by Churchill and Sweet<sup>3, 4</sup> in two cases. Esophagojejunal anastomosis was done but both patients died. In one case there was leakage at the site of anastomosis, while in the other there was widespread sepsis from soiling at operation but the suture line was intact.

More recently, in 1943, Sweet<sup>21</sup> reported seven cases of total gastrectomy by the transthoracic route. He included, in this group of cases, two done by Churchill and himself referred to previously. The other five patients recovered without major complications. In all cases, the choice of transthoracic approach resulted from the fact that the tumor was close to or had actually invaded the cardia and in some cases the lower part of the esophagus as well. The decision to remove the entire stomach was made on the basis of widespread involvement of the organ.

In our opinion when there is no clinical involvement of the lower end of the esophagus as determined by roentgenoscopy with the barium meal or esophagoscopy and when there is no difficulty in swallowing and yet there is diffuse involvement of the stomach likely to entail an extensive resection or total gastrectomy, such resection is best done abdominally. It would seem that the abdominal approach



oneal reflection of the left lobe of the liver from the diaphragm in order to aid in the exposure as advocated first by Turner."

The usual type of procedure consisted of the technic as outlined by Walters, Gray and Priestley.<sup>25</sup> There were a few variations in detail, as for example, in type of suture material used in making the anastomosis and so forth but the fundamentals for the most part were adhered to. In table 3 a summary of the procedures employed is given.

In two cases the method described by Graham<sup>10, 11</sup> was carried out. Of course, in this procedure an entero anastomosis becomes obligatory because in carrying out the technic the proximal jejunal loop is obstructed. Unfortunately in both cases in which the Graham technic was used the patient died. The first patient lived seven days, dying of bilateral bronchopneumonia following extensive atelectasis. Bronchoscopy was performed twice with only temporary benefit. Necropsy revealed an

TABLE 3—SURGICAL PROCEDURES IN 77 CASES

Type of Procedure	Number	Per Cent
"	37	48
"	35	45
"	2	3
"	2	3
"	1	1
Total	77	100

excellent condition of the line of anastomosis and there was no indication of leakage. The second patient expired on the third postoperative day. Necropsy in this case revealed infarction of the jejunal portion of the anastomosis with resultant leakage and peritonitis. This patient had an extensive lymphosarcoma and it was necessary to resect the jejunum because of the presence of a gastro enteric stoma. This probably caused the infarction.

Graham stated that in seven cases in which this technic was utilized there was only one hospital death. Recently, it has been used by Sweet<sup>21</sup> in effecting esophagojejunostomy in three of seven cases in which transthoracic total gastrectomy was performed. In all three cases the result was successful without any evidence of leakage at the anastomosis. The procedure will require further use in order to compare it with the conventional end to side esophagojejunostomy which has been and is at the present time the favored technic at the Clinic.

Esophagoduodenostomy was done in two of the early cases in this series. Both of these patients died in the hospital, one on the thirty fifth postoperative day, the other on the third postoperative day. In the first case, necropsy revealed local peritonitis, abscess and forma

proximal portion of jejunum, thus relieving pressure on the duodenal stump, and also prevent regurgitation of bile up the esophagus, which can be a distressing postoperative symptom.

Note was made of the type of suture material used in the anastomosis. In five cases only catgut was used, in twenty-eight only silk, whereas in forty-four both silk and catgut were used (inner row of

TABLE 4.—TOTAL GASTRECTOMY WITH ASSOCIATED SURGICAL PROCEDURES IN 16 CASES

Associated Surgical Procedures	Cases
Removal of portion of pancreas itself	5
Removal of portion of capsule of pancreas..	3
.....	4
.....	1
.....	1
..... old opening in	1
jejunum.....	1
Resection of 18 inches (46 cm) upper jejunum and mesentery and old gastro-enterostomy with end-to-end anastomosis for ulcerating lymphosarcoma.....	1
Total.....	16

running catgut and outer row of running or interrupted silk). In nineteen (43.2 per cent) of forty-four cases in which both types of suture material were used, the patient died. Likewise, in twelve (42.9 per cent) of the twenty-eight cases in which the anastomosis was made with silk alone, the patient died. Hence, no difference in surgical mortality could be ascribed to the type of suture material used.

TABLE 5.—HOSPITAL SURVIVAL ACCORDING TO IMMEDIATE POSTOPERATIVE METHOD OF FEEDING

Method of Feeding	Total Cases	Survived Operation	
		Number	Per Cent
Jejunostomy tube .	42	19	45
Nasal tube . . .	21	14	67
No tube method .	14	10	71
Total.	77	43	56

One of the problems in the postoperative care of patients after total gastrectomy is the question of feeding during the first few days after operation. This was accomplished by the use of a jejunostomy tube in forty-two (54.5 per cent) of the seventy-seven cases, and by means of a nasal tube passed into the distal limb of the jejunum in twenty-one (27.3 per cent) of the group. By such means, water was first given

via the tube about forty-eight to seventy-two hours postoperatively. This was then followed soon afterwards by administration of high caloric, high vitamin food containing adequate protein, fat and carbohydrate for bodily needs. No method of such tube feeding was used in fourteen (18.2 per cent) of the seventy-seven cases.

From table 5 it can be seen that the hospital survival rate in the three groups was roughly the same, except in those cases in which jejunostomy was performed. This might be explained by the fact that jejunostomy was frequently used in cases of poor risk which at the time of operation, seemed to be the ones in which postoperative difficulties would be most likely to occur. Hence, no deductions can be made fairly from these figures.

The average length of hospitalization for patients with neither jejunostomy tube nor nasal tube was twenty-four days, those with jejunostomy were in the hospital an average of thirty days, while

TABLE 6—EFFECT OF THE IMMEDIATE POSTOPERATIVE METHOD OF FEEDING ON THE TIME IN WHICH DIETS WERE BEGUN

Types of Dietary Feeding	Average Number of Postoperative Days		
	No Tube Used	Jejunostomy Tube Used	Nasal Tube Used
Water by mouth	5.4	4.1	4.7
Water by tube		5.2	5.5
Formula by tube		13.6	13.3
Liquid diet by mouth	9.0	19.9	17.2
Several soft meals taken daily	14.0		

those with the nasal tube method of feeding remained an average of twenty-four days. The total average hospitalization for the entire series was twenty-six days (varying from fifteen to sixty-five days).

In those cases in which neither jejunostomy nor nasal tube feeding was used, advancement of the diet to soft meals was of necessity considerably faster than in those cases in which one of the former methods was used (table 6).

As stated previously, the hospital mortality rate in this series was reduced from 60.6 per cent in the cases in which operation was performed from 1917 to 1939 inclusive to 31.8 per cent during the past four years, 1940 to 1943 inclusive, and 25 per cent during the last year, 1943. Chemotherapy has been in use at the Clinic for this same corresponding time and has undoubtedly played a role in this reduction of the mortality rate. In nearly all cases of total gastrectomy 5 gm. of sulfathiazole or sulfanilamide has been placed directly into the peritoneal cavity routinely. Occasionally, the dose was 10 gm. Chemo-

therapy used in the treatment of postoperative complications likewise has aided in materially reducing the surgical mortality rate

Bronchoscopy was performed in four of the seventy-seven cases. In three of the four cases the patient survived. In these three cases bronchoscopy was performed immediately after the operation was completed. In the fourth case left massive atelectasis developed on the fourth postoperative day. Roentgenograms of the thorax on the second and third postoperative days were negative. Bronchoscopy was performed on the fourth postoperative day and again on the sixth day with considerable improvement of expansion of the involved lung. However, the patient expired seven days after operation. The value of bronchoscopy immediately after operation in those cases in which aspiration of blood and mucus into the bronchi is suspected is evident and its almost routine use after total gastrectomy should appreciably diminish pulmonary complications. Its value has been stressed by Moersch<sup>15</sup> and it will undoubtedly be utilized more and more in the future in extensive surgical procedures in the upper part of the abdomen.

Blood transfusions were given freely to patients whenever needed. Thus, fifty-nine (76.6 per cent) of the seventy-seven patients received from 500 cc to 2,000 cc of whole blood postoperatively. Other supportive measures, of course, were carried out as well. For example, fifty-one (66.2 per cent) of the total group were placed in an oxygen tent for one or more days after operation.

#### POSTOPERATIVE COMPLICATIONS

Bronchopneumonia, with clinical symptoms and signs together with roentgenologic evidence, occurred postoperatively in twenty-three cases (29.9 per cent) (table 7). Although it was the most common postoperative complication, only six patients succumbed with bronchopneumonia as the chief cause of death (table 8). Part of this salvage is due to chemotherapy, while a good share of credit must be given to a recent awareness of the importance of prophylaxis against, and the early treatment of, pulmonary atelectasis with its resultant frequent bronchopneumonia. Thus, after operation patients were encouraged routinely to cough frequently, to take frequent deep breathing exercises and to move about frequently in bed. Often they were forced to breathe deeply by means of inhalations of carbon dioxide for two to three minutes every hour for the first thirty-six to forty-eight hours after operation. In 66.2 per cent of the total cases patients were placed in an oxygen tent for one or more days prophylactically. On the average, they remained in the tent about four to five days unless definite pulmonary pathologic changes were present. We feel satisfied that, had bronchoscopy been utilized more often than it was, the pulmonary complications would probably have been less. Possibly it should be performed routinely after operation. An intra-

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tracheal tube offers the advantage that anesthetists can remove secretion during and at the completion of the operation if it appears in the trachea.

TABLE 7—POSTOPERATIVE COMPLICATIONS

Complication	Number	Per Cent of 77 Cases
Bronchopneumonia	23	30
Peritonitis	14	18
Cardiac failure	11	14
Atelectasis	8	10
Profound shock	7	9
Wound infection	7	9
Others*	24	31

Pack and McNeer<sup>28</sup> have pointed out the value of the injection of eucupine in oil into the intercostal nerves from the sixth to the eleventh thoracic interspace as described by Bartlett and by Zollinger as a means of prophylactic treatment for pulmonary atelectasis. In a

TABLE 8—CAUSE OF DEATH IN 34 CASES FOLLOWING TOTAL GASTRECTOMY

Cause of Death	Cases	Per Cent
Neurogenic shock	16	47
	5	14
	2	6
	1	3
	1	3
	1	3
	1	3
Edema of glottis (death on operating table)	1	3
Left pleural hemorrhage (traumatic perforation of left side of diaphragm)	1	3
Clinical diagnosis (no necropsy)		
Bronchopneumonia	4	12
Cardiac failure	1	3
Total	34	100

large proportion of cases this procedure abolishes pain from the wound and enables the patient to pass through the first two to four post-operative days requiring only an occasional injection of morphine. Furthermore it usually enables the patient to maintain the normal pre-operative level of pulmonary vital capacity.

Peritonitis was the most common cause of death (twenty-one cases or 61.8 per cent). In table 8 it will be noted that in sixteen of the twenty-one cases of peritonitis there was evidence at necropsy of leakage at the line of anastomosis. This fact should serve as a warning to the surgeon in making the anastomosis to use extreme diligence in every step and to place each suture with great accuracy. Even when such care and skill are exercised, there will be occasions of leakage due in all probability, to the poor blood supply to the lower end of the esophagus.

Cardiac failure occurred in eleven cases (14.3 per cent) but was the cause of death in only one case (tables 7 and 8). Pulmonary edema, due to acute heart failure, occurred in only one case and was probably the cause of death there. This, too, is a credit to the careful postoperative management of these patients. Thus, with prompt and forceful therapy, in nine of eleven cases of cardiac failure the patients were salvaged.

The other frequent complication was that of impending shock. In practically all of the cases in recent years fluids were administered intravenously while the patient was on the operating table and whole blood was employed at the slightest indication of impending shock. Hence, we perhaps should limit our remarks to stating that the problem of shock in this group was essentially one of prevention. In no case was shock the primary cause of death.

Wound infection occurred in seven instances which is surprisingly low considering the fact that an open anastomosis was used in a field the esophagus notorious for pathogenic bacteria. In no case was the infection severe and the fascial structures remained intact in all instances (table 7).

Other postoperative complications were occasional or infrequent and are listed in table 7.

Particular notice was made in reviewing these cases as to whether or not there was an unusually marked tendency toward the development of severe anemia. In only four cases was the anemia of note worthy severity and in all the use of iron therapy produced prompt improvement. In two of the four cases there were numbness and tingling of the extremities together with moderately severe glossitis. Blood smears were negative for pernicious anemia and the symptoms promptly disappeared after administration of large doses of vitamins, particularly of the B complex.

Transient diarrhea was occasionally noted during the patient's postoperative period in the hospital, but in only one instance was there persistent diarrhea after the patient was dismissed.

Stricture at the site of anastomosis which necessitated dilatation by means of esophageal bougies occurred in two instances. Both patients, however, obtained adequately functioning stomas and were able to resume their regular diets after such manipulation was carried out.



## PERFORATED PEPTIC ULCER REVIEW OF NINETY SIX CASES

B MARDEN BLACK AND RALPH L. BLACKFORD

IN spite of the interest in acute perforation of peptic ulcer as reflected by the large number of cases which have been reported in the literature, mortality rate associated with the catastrophe has remained appallingly high. Many of the factors which contributed to this high mortality rate are largely beyond the control of the medical attendant but others are directly under the control of the surgeon. Of the latter the method of anesthesia employed, the abdominal incision and the type and extent of the operation are perhaps of the greatest importance. It would seem from a review of the recent literature that although certain trends in treatment are evident there is still some controversy as to the most satisfactory methods.

The many large series of cases of perforated peptic ulcer which have been reported from single institutions,<sup>1, 14, 21</sup> or from single localities,<sup>26</sup> and particularly recent comprehensive reviews of the literature, notably the one by DeBakey,<sup>6</sup> not only have served to establish a large body of fact about the condition but also to make other statistical reports largely superfluous, at least at this time. DeBakey collected more than 20,000 cases which had been reported in the decade preceding 1940, and the findings serve admirably as standards with which the findings in a smaller series may be compared. It is our plan in the present report to comment briefly on the general statistical aspects of the condition and to examine more fully the differences noted in the present series of cases and in the series collected by DeBakey. Finally, the present series was reviewed principally to determine the type of treatment employed by a relatively small group of surgeons.

The present series includes all of the cases of acute free perforation of peptic ulcer of the stomach or duodenum seen at the Clinic during the decade preceding January 1, 1945. Penetrating ulcers and ulcers of the so called *formes frustes* type were excluded from the study. In all, ninety six cases were included, ninety-three of the patients were operated on and three patients, all of whom subsequently died of generalized peritonitis, were considered moribund and were not operated on. During the same decade, approximately 25,000 patients with benign gastric or duodenal ulcer were seen at the Clinic. The overwhelming majority of these patients did not reside in Rochester, Minnesota, or in the immediate vicinity. In eighteen cases in which the patients were transients, perforation occurred while the patients were at the Clinic. Unfortunately, it is not possible even to estimate the average interval that the transient patients spent here. With the excep-

tion of one or two patients who were brought long distances after the perforation developed, the remaining patients who developed perforations lived in the immediate vicinity. The rarity of perforations in this large group of cases of known peptic ulcer is of considerable interest since the patients for the most part were undergoing extensive examination which often required preparation by means of castor oil and enemas, and since virtually all of the patients underwent roentgenologic examination of the stomach and duodenum with barium. In only one case did perforation occur directly after roentgenologic examination of the stomach with barium. In two cases, perforation occurred after the patients had taken an enema.

#### SEX AND AGE OF PATIENTS

In the ninety six cases of perforated peptic ulcer on which this paper is based, ninety-two of the patients were males and four were females. The preponderance of males is in keeping with that observed by other authors.

The age of the patients in our series was materially greater than it was in the cases collected by DeBakey. In DeBakey's series, more than 25 per cent of the patients were less than thirty years of age, more than 50 per cent were less than forty years of age, and slightly more than 6 per cent were sixty years of age or older. In our series, 8 per cent of the patients were less than thirty years of age, 28 per cent were less than forty years, and 17 per cent were sixty years of age or older. The importance of age in relation to mortality is well known. Raw<sup>24</sup> reported that the mortality rate was 7.6 per cent in cases in which the patient's were less than forty-two years of age and 21.3 per cent in cases in which the patients were more than forty-two years of age. In DeBakey's series, the mortality rate in cases in which the patients were in the fourth decade was 18.9 per cent and this figure rose progressively to more than 50 per cent in cases in which the patients were sixty years of age or older. In our series, the hospital mortality rate in the twenty-seven cases in which the patients were less than forty years of age was 4 per cent, in the thirty-three cases in which the patients were in the fifth decade the mortality rate was 12 per cent and in the cases in which the patients were more than fifty years of age the mortality rate was 18 per cent.

#### SITE OF ULCER

The difficulty of determining, at the time of operation, whether the perforated ulcer is situated in the duodenum or stomach is well known and reports vary as to the more frequent site. In DeBakey's series, the site of the ulcer was thought to be in the duodenum in 51.2 per cent, in the stomach in 38.9 per cent and at the pylorus in 9.8 per cent. Yudine,<sup>25</sup> whose figures are based on gross and microscopic examination of resected gastroduodenal segments, found that 90 per cent of

perforated ulcers were situated in the duodenum. In our series of ninety-six cases, eighty-seven of the perforated ulcers were considered duodenal, six were considered gastric and three were judged to be pyloric. The question of the site of a perforated ulcer is of more than academic interest, since the question of malignancy must be considered in all cases of gastric ulcer. We believe that it is impossible to distinguish grossly, in many cases, between benign and malignant ulcers of the stomach, and the microscopic distinction is often so difficult that limited biopsy may be of little value. The only certain method of distinction is careful microscopic examination of the entire ulcer. In view of this, it was not surprising that in two of the six cases of perforated gastric ulcer in the present series a subtotal gastric resection was carried out because the surgeon was not satisfied that the lesion was benign. In both cases, operation was performed within six hours after perforation occurred and recovery from the operation was uneventful.

#### INTERVAL BETWEEN PERFORATION AND OPERATION

The extreme importance of early operation after free perforation of a peptic ulcer is dramatically demonstrated by the results obtained in DeBakey's collected cases. In these cases the mortality rate was as follows: 10.5 per cent in cases in which operation was performed within the first six hours after perforation, 21.4 per cent in cases in which operation was performed between seven and twelve hours after perforation, 38.5 per cent in cases in which operation was performed between twelve and eighteen hours after perforation and 62.4 per cent in cases in which operation was performed between nineteen and twenty-four hours after perforation. In other words, there was virtually a geometric rise in the mortality rate, starting at about 10 per cent in cases in which operation was performed within the first six hours and doubling with the lapse of each period of six hours. After approximately twenty-four hours, the mortality rate did not increase and it is probable that patients who survive operation done after the lapse of twenty-four hours would have recovered without operation. There is a rather marked tendency for a perforated ulcer to become sealed and, if the patient is still in sufficiently good condition to undergo operation, it is probable that the perforation has become sealed. In this case conservative treatment, including constant gastric suction, may well be indicated. Subsequent drainage of a localized intraperitoneal abscess may become necessary. In this connection Wakeley<sup>28</sup> recently has emphasized that constant gastric suction should be employed from the time the patient is first seen until the perforation can be closed, since it is obviously not the elapsed time per se between perforation and closure which is dangerous but the amount of soiling which has taken place during this time.

The patients in the present series were seen, on the whole, relatively

soon after perforation had occurred. Forty-six patients were operated on within the first six hours, twenty-eight within the second six hours, twelve between twelve and twenty-four hours and five after more than twenty-four hours had elapsed. In two cases the interval between perforation and operation could not be determined from the records. In eleven of the ninety-three cases in which operation was performed, the patients died in the hospital. Although this number of deaths is too small to warrant any particular analysis, it may be of interest to correlate the mortality rate with the interval that elapsed between perforation and operation. According to the time that elapsed between perforation and operation, the mortality rate was as follows: 11 per cent in the forty-six cases in which operation was performed within six hours after perforation occurred, 7 per cent in the twenty-eight cases in which operation was performed six to twelve hours after perforation and 25 per cent in the seventeen cases in which operation was not performed until twelve or more hours had elapsed.

#### DIAGNOSIS

The diagnosis was correct in virtually all of the ninety-three cases in which operation was performed, at least, the necessity for an exploratory laparotomy was recognized. Other acute diseases of the abdomen, particularly, fulminating acute appendicitis and less frequently, acute cholecystitis, acute pancreatitis and intestinal obstruction, not uncommonly are mistaken for perforated peptic ulcer. In order to distinguish perforated peptic ulcer from acute pancreatitis, we recently have initiated the practice of determining the concentration of amylase and lipase in the serum in all cases in which the presence of a perforated peptic ulcer is suspected.

In eighty-three of the ninety-six cases, the clinical history contained a notation regarding the presence or absence of symptoms of peptic ulcer. In seven cases, the patients never had had any indigestion suggestive of peptic ulcer. In the remaining seventy-six cases, symptoms of peptic ulcer had been present for the following periods: less than one year in thirteen cases, from one to five years in seventeen cases and for five years or more in forty-six cases. In one case, the symptoms had been present for more than forty years before perforation occurred. Such findings suggest that perforation may occur at any time, as long as the ulcer remains active, and that symptoms usually have been present for a long time before perforation occurs.

#### TREATMENT

It is our belief that the judicious choice of the method of anesthesia, the use of small incisions and the limitation of the operation to simple closure of the perforation preferably by patching should be followed by the best immediate recovery rate. Since these are the most impor-

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It is our belief that the judicious choice of the method of anesthesia, the use of small incisions and the limitation of the operation to simple closure of the perforation preferably by patching should be followed by the best immediate recovery rate Since these are the most impor-

tant factors affecting the outcome and can be controlled by the surgeon,\* we shall consider them rather fully.

**Anesthesia**—There is still lack of agreement as to the type of anesthesia which should be employed in the management of acute perforation of a peptic ulcer although there is a definite trend toward spinal anesthesia. Eliason and Ebeling<sup>9</sup> in 1934 stated that ether or ether and nitrous oxide and oxygen had been employed in the majority of their collected cases and they emphasized that spinal anesthesia was the only method of anesthesia charged with a death in their series. DeBakey, six years later, said that the majority of recent observers considered spinal anesthesia the method of choice. More recently, the trend toward spinal anesthesia has been even more marked. McClure<sup>18</sup> found that the mortality rate with general anesthesia was six times as great as with spinal anesthesia. Many other authors<sup>8, 16, 17, 19, 21</sup> have expressed the same opinion. Conversely, Trout<sup>17</sup> recommended general anesthesia because of the low blood pressure frequently seen, particularly in cases of late perforation and Griswold and Antonic<sup>12</sup> reported that they have discontinued the use of spinal anesthesia because of three deaths which they attributed to vascular collapse, the result of the spinal anesthesia. Berson<sup>4</sup> reported that, although spinal anesthesia frequently was unsatisfactory, general anesthesia was associated with a higher operative risk in his series of cases.

We feel, in general, that ether, used alone or in conjunction with other anesthetic gases and oxygen, has serious disadvantages when employed in cases of perforated peptic ulcer. The amount of ether required and the time necessary to secure adequate relaxation of the extreme spasm of the abdominal muscles are both great, and the violent respiratory excursions which frequently occur with general anesthesia must tend to disseminate widely any contaminating fluid which may be present in the peritoneal cavity. Single dose spinal anesthesia has the obvious disadvantage that the anesthesia may not last for the duration of the operation. However, if the surgeon plans to limit the operation to simple closure of the perforation, a single small dose of a spinal anesthetic should provide adequate time to carry out this procedure in an orderly manner. It is our practice, as a rule, to employ general anesthesia in operations on the stomach, because we are feeling that the large dose of a spinal anesthetic necessary to provide anesthesia of adequate duration for the usual elective gastric operation is more dangerous than general anesthesia. This objection does not hold in cases of perforated peptic ulcer since simple closure can be done in a few minutes, and, as a consequence, small doses of the anes-

\* Sulfathiazole or sulfamylamide in amounts varying from 5 to 20 gm. was left in the peritoneal cavity in virtually all cases in which operation had been performed in the past six years. The hospital deaths in the series were so few and were affected by so many other factors that any estimate of the value of chemotherapy in these cases was not possible.

thetic agent may be employed. Conversely, if the decision as to whether the operation is to be long or short cannot be made before the abdomen is opened, the method of anesthesia chosen must provide sufficient time for a prolonged procedure. Under such circumstances general or continuous spinal anesthesia probably would be safer than prolonged, single-dose spinal anesthesia. In the great majority of cases in which simple closure was performed in the present series, the operation required less than forty-five minutes while in only three of the cases in which simple closure was followed by gastro-enterostomy was it possible to complete the operation in sixty minutes or less.

Cyclopropane or nitrous oxide and oxygen anesthesia recently has been used at the Clinic in conjunction with the intravenous administration of curare for the closure of perforated peptic ulcers with considerable success.<sup>2</sup> With this combination of agents the general anesthesia may be very light since adequate muscular relaxation is obtained readily by means of the curare. The muscular relaxation compares favorably with that produced by spinal anesthesia and the operation may be prolonged at will by subsequent intravenous injections of curare. It should be pointed out that curare is still under clinical trial and that sufficient data have not been assembled to permit a final evaluation of this drug.

Local anesthesia, used either alone or in conjunction with intravenous anesthesia or inhalation anesthesia, has an obvious place in the treatment of certain cases in which the surgical risk is very high. Such methods were not used in the present series.

**Incision.**—The frequency of wound complications following operation for perforated peptic ulcer is well known. Wound infection or evisceration occurred in 28.9 per cent of the cases reported by DeBakey and Odom<sup>7</sup> from the Charity Hospital in New Orleans. Shelley<sup>22</sup> reported that separation of a wound occurred in five of eighty-two cases; Meade<sup>20</sup> reported that in 25.6 per cent of ninety cases the wounds failed to heal by primary intention and that in four of the ninety cases disruption of the wounds occurred. Kelly<sup>16</sup> stated that wound infection occurred in 37 per cent of 152 cases and that in six of these disruption of the wound occurred. Wound infection occurred in twelve of the ninety-three cases in which operation was performed at the Clinic and evisceration occurred in one of the cases.

Of the several methods which have been proposed to minimize the consequences of wound infection and poor healing, the use of non-absorbable sutures, small vertical or transverse incisions, and secondary and delayed closure of wounds would seem to be the most important. It is apparent that small incisions possess advantages over large incisions in the surgical treatment of any condition associated with a high incidence of infection and evisceration. The incision must be of adequate length to provide reasonable exposure but, if simple closure of the perforation alone is contemplated, the incision may be kept materially



smaller than it can if closure of the perforation is to be followed by gastro enterostomy. We prefer a small incision (8 to 10 cm.) high in the right rectus muscle. The incision is closed with nonabsorbable interrupted sutures which include all of the layers of the abdominal wall. In addition to the retention sutures, which are placed approximately 15 cm. apart, the individual layers are sutured with surgical catgut. The advantages of delayed closure of the skin and subcutaneous tissues in cases of contaminated wounds have been pointed out previously by Pemberton and one of us (B.M.B.)<sup>13</sup> and this method of closure is employed when the degree of contamination is great. Griswold and Antonic,<sup>12</sup> Amendola,<sup>1</sup> and Hartzell and Sorock<sup>14</sup> have advocated the use of a transverse incision. Whatever type of incision is employed, it must be adequate to afford ample exposure, not only of the perforation but also of sufficient stomach and duodenum so that there can be reasonable certainty that multiple perforations are not present.

**Surgical Treatment of the Perforation**—Simple closure of the perforation is the least extensive procedure which can be carried out and the operative risk should be less than with other more extensive operations. The addition of gastro enterostomy to the operation of simple closure has been thought necessary most often because of the possibility of the formation of a stricture at the site of the closure and less often, because of the supposed danger of leakage at the site of closure unless drainage of the stomach by means of a gastro enterostomy has been provided. Many authors<sup>11, 28</sup> have commented on the fact that an apparent stenosis will relax sufficiently to permit satisfactory emptying of the stomach. However, some stenosis almost invariably results from the perforation and closure if either the traditional two layer closure or purse string closure of the perforation is carried out and in some cases the induration and friability of the tissues surrounding the opening are so great that the closure of the opening by sutures is not only technically difficult but also insecure. These problems may be eliminated almost entirely if the perforation is closed by patching either with attached omentum or a free omental graft. This method was employed as early as 1896<sup>3</sup> and recently has been endorsed enthusiastically by Graham<sup>15</sup>. Graham recommended passing three catgut sutures in the longitudinal axis of the bowel, one through, one above and one below the ulcer, and tying them loosely over a small portion of adjacent greater or lesser omentum. There has been ample clinical proof that this method of closure is secure. If drainage of the stomach is deemed necessary, an inlying tube with constant gravity suction may be employed. Simple closure, either by suture or by patching, was used in seventy six of the ninety three cases in our series. Patching was used more frequently than closure with sutures during recent years and in our opinion, the method is clearly superior to closure of the perforation with sutures.

A comparison of the mortality rates in cases in which simple closure was employed alone with the mortality rates in cases in which simple closure was followed by gastro enterostomy furnishes overwhelming evidence in favor of the use of simple closure alone. Death occurred in seven (9 per cent) of the seventy-six cases in which simple closure was employed alone and in four (27 per cent) of the fifteen cases in which simple closure was followed by gastro-enterostomy. During the same period covered by this study, the mortality rate was less than 2 per cent in cases in which gastro enterostomy was performed at the Clinic for chronic or subacute duodenal ulcers. It is evident that any supposed advantages to be gained by the addition of gastro enterostomy to simple closure do not warrant an operative risk almost three times as great as that associated with simple closure alone or more than thirteen times as great as that associated with elective gastro enterostomy for unperforated duodenal ulcers.

Of other surgical methods which have been proposed for acute perforation, some mention should be made of excision and pyloroplasty. Donald and Barkett<sup>8</sup> have reported that pyloroplasty reduced from 39 per cent to less than 10 per cent the number of patients who had a recurrence of digestive symptoms and they advocated the use of this procedure in certain cases. Pyloroplasty was not performed in any case in our series but, in the past, it occasionally has been employed with satisfactory results in cases in which perforation is associated with stenotic obstruction. Other authors including Hinton<sup>15</sup> have reported that the results of pyloroplasty were no better than those of simple closure. Gastric resection was carried out in two of the ninety-three cases in our series. In both cases, large callous gastric ulcers had perforated and resection was carried out because of the possibility that the ulcers were malignant. In three cases a Witzel type of jejunostomy was performed in addition to other operative procedures, for purposes of feeding.

#### COMPLICATIONS

The complications observed in our series of cases were those usually seen after operations for perforated ulcer. Of the eleven hospital deaths in the series of ninety-three cases in which operation was performed, six were due to peritonitis (localized in one case), three were due to bronchopneumonia and two to pulmonary embolism. Of the nonfatal complications, those pertaining to the incision in the abdominal wall were the most numerous. The wound became frankly infected in ten cases, in four of these cases considerable separation of the wound occurred and in one case nonfatal evisceration developed. Localized intraperitoneal abscesses developed in three cases and pulmonary complications, such as pulmonary embolism, atelectasis and bronchopneumonia, were observed in seven cases. In one case gastric retention developed after simple closure and in another case it developed after

closure and gastro enterostomy. Parotitis and thrombophlebitis each were observed in two cases. Finally, the three patients who were not operated on died of generalized peritonitis.

### PROGNOSIS

Although reports vary as to the number of patients who have persisting symptoms after recovery from acute perforation, there is general agreement that a large percentage of such patients will continue to have symptoms of peptic ulcer.<sup>12, 19, 22</sup> It is rather difficult to understand why the perforation and its subsequent closure would in any way modify the tendency for other ulcers to form, however, many patients apparently are relieved of subsequent ulcer symptoms after the perforation and it is partly because of this that operations designed to change the physiology of the stomach are, as a rule, not considered necessary in cases of acute perforation. Eusterman and Balfout<sup>19</sup> estimated that approximately half of the patients who recover from perforation will remain free of symptoms of peptic ulcer. In approximately two thirds of DeBakey's collected cases the patients remained reasonably well after their recovery from the acute perforation. More recent reports are in keeping with this finding. Marshall and Keleher<sup>12</sup> reported that symptoms persisted in 55 per cent of their cases, and Harrison and Cooper<sup>13</sup> reported that less than 20 per cent of patients remained free of symptoms of an ulcer.

It is evident from such reports that patients who have recovered from a perforation should be considered in the same light as other patients who have a peptic ulcer and that subsequent medical or surgical management should be advised, depending on the individual case. In arriving at a decision as to whether subsequent elective operation is advisable, some weight probably should be given to the fact that perforation has occurred since repeated perforation is not uncommon. Shelley<sup>23</sup> was able to follow fifty nine of sixty seven patients who survived one perforation for one or more years and he reported that three of the patients had required operation for a second perforation. Cohn<sup>5</sup> reported that in a series of approximately 300 cases of perforation there were twelve instances of recurrent perforation.

In our series of cases no formal attempt at a follow up study was made. However, the subsequent condition of approximately half of the patients who recovered was known for one or more years after the perforation. Approximately a third were well, and of the two thirds who were not well, approximately a third had undergone a further operation because of symptoms of ulcer. In six of the eleven cases in which the patients survived simple closure and gastro enterostomy, follow up data were available for one or more years after the perforation had occurred. Three were free of symptoms and three continued to have symptoms of ulcer.

## SUMMARY AND CONCLUSIONS

Of the ninety-six patients in this series, ninety-three were operated on and three were considered moribund when first seen and were not operated on. The series was somewhat unusual in that the patients were generally older than those of many other comparable series. There were eleven postoperative deaths.

Spinal anesthesia would seem to possess advantages over general anesthesia for the operation of simple closure. Continuous spinal anesthesia or general anesthesia probably should be chosen for the operation of closure and gastro-enterostomy. The use of light general anesthesia combined with curare to secure muscular relaxation has great promise and may well become the anesthetic choice.

Because of the high incidence of complicated healing of the incision in the abdominal wall, the incision should be kept as small as is compatible with adequate exposure. Incisions may be smaller when simple closure is used alone. Nonabsorbable retention sutures, incorporating all layers of the abdominal wall, and delayed closure of the skin and subcutaneous tissues probably will decrease serious complications in the wound.

The operation should be limited to closure of the perforation in virtually all cases of perforated duodenal ulcer. In some cases of perforated gastric ulcer, subtotal gastric resection may be indicated. Closure of the perforation and gastro-enterostomy was associated with a hospital mortality rate almost three times as high as that associated with closure alone and more than thirteen times as high as that associated with gastro-enterostomy in the absence of free perforation.

Patients who have recovered from a perforation should receive further medical or surgical treatment, depending on the findings in the individual case. The fact that perforation has occurred should receive some weight in the consideration of further elective operation.

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# DISEASES OF THE GALLBLADDER· DIAGNOSIS AND MANAGEMENT

O THERON CLAGETT

THE diagnosis and management of diseases of the gallbladder constitute a problem of major importance to every physician and surgeon. This is evidenced not only by the voluminous literature on the subject of cholecystic disease but also by daily experience in the clinical practice of medicine and surgery.

It is obviously impossible to cover the whole subject of cholecystic disease but I shall discuss a few aspects about which some controversy still exists. In spite of the vast amount of work that has been carried out concerning the etiology of cholecystic disease, fundamental knowledge on this subject is so inadequate that it had best be ignored for the present. Instead, this paper will be devoted to phases of the subject about which definite knowledge is available.

## INCIDENCE

The gallbladder and bile ducts are more frequently involved by disease than is any other portion of the biliary tract. Furthermore, of the gastro intestinal tract and its accessory organs, the biliary tract is most often the site of disease, and this incidence probably will increase with the passage of time. This prediction is based on the fact that there is a well known trend in the age composition of the population in this country toward higher age levels and the fact that the incidence of cholecystic disease increases with each decade of life. It is estimated that by 1950, 40 per cent of the population, or about 50,000,000 people, will be more than forty-five years of age and 15 per cent will be more than sixty-five years of age.

Eliason and Stevens<sup>4</sup> have stated that 15 per cent of people in the United States suffer from biliary disease and that this figure increases to 30 per cent among individuals beyond forty-five years of age. Crump<sup>5</sup> has reported that on postmortem examination of patients who at the time of death had been more than forty-five years of age, stones were found in 33 per cent and evidence of cholecystic disease was found in 60 per cent. With such a high incidence of disease in this organ it is not surprising that Miller<sup>6</sup> has reported that among patients treated in the gastro-enterology clinic of the University of Pennsylvania hospitals 40 per cent of complaints were attributable to disease of the biliary tract. These statistics emphasize the importance of cholecystic disease as a cause of symptoms referred to the gastro-intestinal tract and its accessory organs.

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Eliason and Stevens<sup>4</sup> have stated that 15 per cent of people in the United States suffer from biliary disease and that this figure increases to 30 per cent among individuals beyond forty-five years of age. Crump<sup>3</sup> has reported that on postmortem examination of patients who at the time of death had been more than forty-five years of age, stones were found in 33 per cent and evidence of cholecystic disease was found in 60 per cent. With such a high incidence of disease in this organ it is not surprising that Miller<sup>6</sup> has reported that among patients treated in the gastro enterology clinic of the University of Pennsylvania hospitals 40 per cent of complaints were attributable to disease of the biliary tract. These statistics emphasize the importance of cholecystic disease as a cause of symptoms referred to the gastro intestinal tract and its accessory organs.

Robertson and Dochat<sup>5</sup> at the Mayo Clinic recently reported some



interesting figures on the incidence of cholecystic disease and gall stones with reference to age (table 1). In women there is a rather sudden increase in incidence from 6 per cent in the third decade of life to 12.4 per cent in the fourth decade, whereas in men the increase in each decade is more gradual and the greatest increase of incidence occurs in the sixth decade with an augmentation of 9.7 per cent in the fifth decade to 15.4 per cent in the sixth.

These findings confirm the clinical experience of most physicians that among women cholecystic disease is likely to develop at an earlier age than among men. These figures also demonstrate, again, that women are particularly prone to the development of cholecystic dis-

TABLE 1—POSTMORTEM INCIDENCE OF GALLSTONES  
ACCORDING TO AGE AND SEX OF PATIENTS\*

Age in Years	Total Number of Cases Examined	Cases With Gallstones		Males			Females		
				Number of Cases Examined	Cases With Gallstones		Number of Cases Examined	Cases With Gallstones	
		Num- ber	Per Cent		Num- ber	Per Cent		Num- ber	Per Cent
0-9	1,432	2	0.1	810	4	0.1	662	1	0.2
10-19	662	3	0.5	378	1	0.3	284	2	0.7
20-29	1,190	49	4.1	628	15	2.4	562	34	8.0
30-39	1,957	176	9.0	1,092	69	6.3	865	107	12.4
40-49	2,921	434	14.6	1,735	189	9.7	1,186	265	22.3
50-59	3,765	788	21.0	2,410	372	15.4	1,355	416	30.7
60-69	3,285	795	24.2	2,291	410	17.9	994	385	38.7
70-79	1,395	414	29.7	1,016	237	23.3	379	177	46.7
80+	284	93	32.7	192	53	27.6	92	40	43.5
Not stated	45	11		35	5		10	6	
Total	16,936	2,765	16.3	10,587	1,332	12.6	6,349	1,433	22.6

case. Although in this series of postmortem examinations there were almost twice as many men as women (10,587 and 6,349, respectively) nearly twice as many women as men had gallstones (22.6 and 12.5 per cent, respectively).

The fact that women are afflicted more frequently with cholecystic disease and gallstones than are men raises the question of the relationship of pregnancy to development of cholecystic disease. In the literature the statement repeatedly is made that pregnancy is a major factor in the causation of gallstones in women and thus has been accepted generally as a fact. However, Robertson and Dochat recently analyzed carefully the available data and were unable to confirm this common belief. As they pointed out, the predisposing effect of pregnancy on

production of gallstones can be proved only by demonstrating that the percentage of gallstones in women who have borne children is appreciably greater than in women who have not borne children. They pointed out that statistics show that 13 per cent of all married women in the United States have borne no children and an additional 78 per cent of women never have married, which makes a total of about 20 per cent of women who have borne no children. Therefore about 80 per cent have borne children. From the records of the post mortem examinations made at the Mayo Clinic, Robertson and Dochat found that of 1,413 women with gallstones, 1,185 (83.9 per cent) had had pregnancies. In a similar survey of the records of 6,106 women in whom gallstones were present at operation, it was found that 4,876 (79.9 per cent) had been pregnant. Therefore, there is no appreciable difference with reference to development of gallstones between the number of women who have borne children and the number of women who have not borne children. It must be admitted, however, that even though pregnancy is not an etiologic factor in the causation of gallstones, the factors that are responsible function more effectively and at an earlier age in women than in men.

#### DIAGNOSIS

The clinical manifestations of cholecystic disease, which may be either acute or chronic in nature, are well known and will not be discussed at length. It must be kept in mind constantly, however, that the symptoms are varied and often fail to follow the textbook picture. The fair, fat, flabby, fertile, flatulent female of forty with a pain in the upper part of the abdomen, described by Owens,<sup>7</sup> may be typical of the patient with cholecystic disease but this condition also occurs frequently in patients with other physical characteristics and may produce symptoms suggesting peptic ulcer, coronary disease, diaphragmatic hernia and appendicitis to mention only a few. Therefore, the possibility of cholecystic disease must be considered in nearly all complaints involving the gastro intestinal system. In general, as pointed out by Sanders,<sup>10</sup> patients can be divided, according to the predominating clinical symptoms into three main groups namely, (1) those with pain usually manifested by recurring bouts of biliary colic (2) those with digestive disturbances, qualitative food disturbances, belching and flatulence and (3) those with both biliary colic and digestive disturbances.

It is fortunate that in the diagnosis of cholecystic disease a test as simple and reliable as cholecystography is available. A laboratory test should not be used to the exclusion of taking a complete history, performing an adequate physical examination and exercising good clinical judgment, but in dealing with a condition of which the manifestations are varied and in which all diagnostic resources must be employed, a test such as cholecystography is invaluable. At the Clinic, 98 per cent

of patients who have abnormal cholecystograms are found at operation to have disease of the gallbladder. Ninety nine per cent of patients who have gallstones give positive cholecystographic evidence of their disease. In some cases in which the dye cannot get into the gallbladder because it is so extensively diseased stones which cannot be demonstrated by cholecystographic examination are present. These cases cause the physician particular concern because he knows from other evidence that the gallbladder is seriously diseased and also that more than 90 per cent of such patients have stones even though they are not visualized roentgenographically.

The diagnosis of acute cholecystitis is not difficult. In more than 90 per cent of cases there is a past history of cholecystic disease often with minor attacks of biliary colic. The attack is characterized by the onset of acute abdominal pain increasing in severity and accompanied by nausea and vomiting. Elevation of the leukocyte count and of the temperature is not remarkable in the early stages of an attack. This emphasizes the fact that attacks of acute cholecystitis are primarily obstructive rather than inflammatory in nature. In most cases infection does not play an important part until after forty eight hours and in about half of the cases cultures of the contents of the gallbladder in the first forty eight hours are sterile. There usually is some definite tenderness in the right upper quadrant of the abdomen and the gallbladder is palpable. In the opinion of Saint<sup>9</sup> the development of a palpable gallbladder is the most important clinical manifestation that the pathologic process has progressed to a point of impending perforation.

Elason and Stevens noted that usually the diagnosis of acute cholecystitis in women is easier than in men. They pointed out that pain in the upper part of the abdomen in women immediately suggests cholecystic disease whereas in men it may suggest first a perforated ulcer or coronary disease. Furthermore, Elason and Stevens stated that the more lateral location of the gallbladder in the male may result in symptoms that suggest acute appendicitis, kidney disease or a lesion of the right portion of the colon.

In many cases the degree of cholecystic disease is extremely difficult to evaluate and the pathologic process may be out of proportion to its clinical and laboratory manifestations. The experience of Elason and Stevens emphasizes that laboratory and clinical examinations cannot be relied on to provide this information. They reported that in 135 pathologically proved cases of acute cholecystitis 21 per cent revealed a normal leukocyte count, 23 per cent a normal temperature, 30 per cent no palpable mass, 28 per cent no history suggestive of cholecystic disease and 4 per cent not even local tenderness on physical examination. Most other physicians probably also have been impressed as I have been by the number of times acute cholecystitis has been found in a patient with a normal leukocyte count and a normal temperature.

Often the patient has been eating regularly without distress and has been carrying on his regular duties. His only complaint may be of a little soreness in the right upper part of the abdomen and a past history of cholecystic disease. A disease that can hide itself so effectively must be looked on with great concern.

The criteria necessary for a diagnosis of cholecystic disease of sufficient severity to warrant operation are as follows: (1) a satisfactory history of one or more attacks of biliary colic or its equivalent, with or without fever, chills and jaundice, (2) residual soreness in the region of the gallbladder following episodes of biliary colic, (3) indigestion which is usually characterized by flatulence, bloating and discomfort, (4) a cholecystogram that gives evidence of a nonfunctioning gallbladder or of the presence of stones and (5) reasonably exact exclusion of conditions that simulate cholecystitis.

#### MANAGEMENT

From a therapeutic standpoint, diseases of the gallbladder can be divided into three main groups, as follows: (1) chronic noncalculous cholecystitis, (2) chronic cholecystitis with stones and (3) acute cholecystitis.

**Chronic Noncalculous Cholecystitis.**—I do not believe that chronic noncalculous cholecystitis warrants operation since it does not fulfill the necessary criteria for such a procedure. In an occasional case the symptoms may be relieved by cholecystectomy but in general these patients do not obtain good results from operation. This group includes particularly those patients who have a vague type of dyspepsia and abdominal discomfort but who have not had biliary colic and do not have positive cholecystographic evidence of disease. This group of patients should be treated conservatively. They probably will continue to complain under any type of medical management because their complaints are usually on a functional rather than on an organic basis. Poor results attributable to ill-advised surgical procedures in such cases should not be allowed to discredit the good results following operations performed under proper indications.

**Chronic Cholecystitis with Stones.**—A history of cholecystic disease manifested by biliary colic, indigestion or both with cholecystographic evidence of stones or a nonfunctioning gallbladder constitutes definite indication for surgical treatment, provided, of course, that the patient's general condition will permit operation. The literature is filled with arguments, pro and con, concerning the dangers associated with the presence of gallstones. Personally, I am convinced that so-called innocent gallstones do not exist and that they should be removed. There is no medicine or diet that will protect a patient with gallstones against serious trouble and such trouble may require an operation at an inopportune time under unfavorable circumstances. The physician who tells a patient not to bother the gallstones until they bother him is assum-

ing undue responsibility. The risk of cholecystectomy performed on a patient in good general condition for chronic cholecystitis with stones is a fraction of 1 per cent and usually a good result ensues. If surgical treatment is not undertaken the patient usually will continue to have some indigestion and distress. In addition, biliary colic, an ever present hazard, may occur. This may be complicated by acute obstructive cholecystitis that requires an emergency operation with all its attendant risks.

If further evidence of the advisability of surgical treatment of patients who have chronic cholecystitis with stones is necessary, the follow-up study made by Jaguttis<sup>5</sup> of 114 patients with cholelithiasis may be considered. These patients had been treated conservatively for from ten to twenty-five years. In five cases carcinoma of the gallbladder developed, in thirteen cases the patients died of cholecystic disease and in twenty-five cases the patients finally were operated on for complications. Four of these twenty-five patients died. The incidence of carcinoma of the gallbladder reported in this series of 114 cases is high, since other reports indicate that carcinoma develops in only 2 to 5 per cent of cases in which gallstones are present. It is well known that carcinoma of the gallbladder almost never occurs in the absence of stones.

I look with particular concern on all cases of cholecystic disease in which a nonfunctioning gallbladder is reported on cholecystographic study. A follow-up study of a series of 150 such patients seen at the Mayo Clinic who refused surgical treatment revealed that, within two years after the diagnosis had been made, 27 per cent of patients had been operated on for serious complications of cholecystic disease, such as jaundice, pancreatitis and perforated gallbladder. This illustrates the danger of delay of surgical treatment in this group of cases.

As already has been pointed out, the incidence of cholecystic disease increases with every year of life, the condition being particularly common among persons who are more than forty-five years of age. Postmortem statistics show that 25 to 30 per cent of all persons more than sixty years of age have chronic cholecystitis with stones. Should patients be denied surgical relief merely because of advanced age? No, I do not think so, provided, of course, their general physical condition is satisfactory. Indigestion and pain are distressing regardless of age. In addition, in the presence of a condition such as cholecystitis with stones, in which the possibility of an emergency operation under unfavorable circumstances is ever present, an elective operation is even more urgent than in younger patients. Older patients tolerate surgical treatment satisfactorily if the time selected for operation is opportune and the preoperative preparation is adequate.

Recently, at the Mayo Clinic, a series of 1,204 patients more than sixty-five years of age on whom major surgical procedures had been performed were reviewed.<sup>1</sup> Table 2 shows the results obtained in 197

cases in this series in which biliary operations were performed. The interesting fact is that death occurred only in cases in which operation was performed as an emergency measure or in cases in which there were serious complications of cholecystic disease, such as pancreatitis, hepatitis, jaundice or cholecystoduodenal fistula.

It should be pointed out that none of the serious complications of cholecystic disease with stones can be prevented by any medical or dietary treatment now available. Of course, many persons die of lesions not connected with the biliary tract and are found at postmortem examination to have gallstones. Obviously, no patient should undergo cholecystectomy if he has other conditions that make the surgical risk greater than the risk resulting from the presence of cholecystic disease. On the other hand, with proper preoperative care, the condition of most patients, regardless of their age, can be improved sufficiently to

TABLE 2—BENIGN DISEASES OF THE GALLBLADDER  
AND BILE DUCTS

Operations	Cases	Deaths in Hospital	
		Number	Per Cent
Cholecystectomy	133	8	6
Alone	78	4	5
With choledochostomy	55	4	7
Cholecystostomy	47	6	13
Alone	26	4	15
With choledochostomy	21	2	10
Other procedures	17	2	12
Total	197	16	8

permit elective cholecystectomy. Thus, they are relieved of both the distress and the danger associated with the presence of cholecystic disease with stones.

**Acute Cholecystitis**—Acute cholecystic disease comprises about 20 per cent of all diseases of the biliary tract encountered in medical and surgical practice. Since this condition is so frequent and since its management is more controversial than that of any other phase of biliary disease, it is important that its nature be well understood.

The term 'acute obstructive cholecystitis' is more descriptive of the pathologic condition present than is the term 'acute cholecystitis'. These acute attacks of biliary colic result from obstruction of the cystic duct, usually by a stone rather than by any primary inflammatory condition. The pathologic course of events that results has been summarized by Saint: Acute obstruction with or without infection.

leads to increased intravisceral tension. Colicky pain results from the efforts of the gallbladder to empty itself. The increased intravisceral tension in the gallbladder results in interference with blood supply and the development of gangrene in this organ, usually beginning in the fundus since it is farthest from the source of blood supply. Gangrene results in perforation of the gallbladder. As Stout and Hibbard<sup>11</sup> have pointed out, perforation of the gallbladder may be of five types, namely, (1) perforation with communication with another viscus usually the duodenum, colon or stomach, (2) perforation with formation of a pericholecystic abscess, (3) acute free perforation, (4) perforation into the liver and (5) external perforation.

This entire sequence of events in attacks of acute obstructive cholecystitis can, of course, be interrupted at any point if the obstructing stone becomes dislodged and the contents of the gallbladder are released through the cystic duct into the common duct and duodenum. In biliary colic of a few minutes or in hours duration the obstruction is released in this way. A biliary colic of short duration obviously does not constitute an attack of acute cholecystitis since serious pathologic changes do not develop. An attack of biliary colic of more than a few hours' duration should cause concern, however, because perforation has occurred in as short a time as twenty-four hours. In a series of 2,261 cases of acute cholecystitis reported by Cowley and Harkins<sup>12</sup> perforations had occurred in 13 per cent of the cases.

Obviously, if an attack of acute cholecystitis develops, the patient should be treated surgically. The only question concerns the most advantageous time of operation.

Conservative management of acute cholecystitis, that is, medical treatment followed by elective cholecystectomy, requires hospitalization, often for some weeks, during the acute phase of the disease. This is often a serious economic factor because of time lost from work as well as expense of hospitalization during medical treatment. In addition there is the cost of cholecystectomy which ultimately will be necessary anyway, and of hospitalization during surgical treatment. During the period of conservative treatment the patient suffers pain. There is also the ever present danger of the necessity of emergency operation perhaps under unfavorable circumstances.

In my opinion, patients with acute cholecystitis should be operated on within forty-eight hours of an attack, provided, of course, that a well-trained surgeon and the necessary facilities are available and the patient's general condition will permit operation. An immediate operation results in a saving of time and money for the patient and more important, it prevents suffering and minimizes the risk.

As mentioned previously, perforation occurs in 13 per cent of all cases of acute cholecystitis. The dangers of such a complication are well known. If the perforation is localized to a pericholecystic abscess, the only treatment that can be performed is drainage, and chole-

cystectomy must be reserved for a future time. If the gallbladder perforates into the duodenum, colon or stomach the acute attack may be relieved and the patient may survive. Subsequent surgical procedures on this group of patients are attended with many difficulties and much danger.

On the other hand, if operation is performed within forty-eight hours of an attack, it usually is not difficult or hazardous. As I mentioned earlier, infection does not play an important part in the pathologic picture within the first forty-eight hours. The tissues are edematous but have not yet become indurated and friable. The risk of peritonitis is negligible. It is usually possible to carry out cholecystectomy without difficulty, in fact, some of the operations that I have performed in cases of acute cholecystitis have been extremely easy, the edema in the tissues controlling oozing and resulting in an excellent line of cleavage for the dissection. I have not hesitated to explore the common duct when it has been indicated. If cholecystectomy apparently cannot be performed accurately and safely because of difficulties in obtaining adequate exposure, there should be no hesitation about performing cholecystostomy instead. This operation always can be done easily, entirely under local anesthesia, if necessary. Elison and Stevens reported that cholecystostomy had been curative in 84 per cent of their cases of acute cholecystitis. The experience of surgeons of the Mayo Clinic has been similar.

I do not mean to convey the impression that an emergency surgical procedure should be performed on every patient with biliary colic. I do believe, however, that acute obstructive cholecystitis is a surgical not a medical, condition and that the patient's interests are best served by operation early in the course of the attack. I agree with Elison and Stevens that the surgeon should recognize his own, as well as the patient's limitations and that unless conditions are favorable for cholecystectomy, cholecystostomy is the preferable procedure. Operation can be delayed as long as necessary to combat dehydration and to get the patient into the best possible condition. I firmly believe, however, that with proper preoperative and postoperative care, early operation that is within the first forty-eight hours of the attack can be carried out with less risk and suffering and with saving of time and money for the patient.

#### SUMMARY

The incidence of cholecyctic disease is increasing as the age composition of the population reaches higher levels. Women are afflicted twice as frequently as men and at an earlier age. Contrary to general opinion, pregnancy has no effect on the incidence of cholecyctic disease. Cholecystography is an invaluable aid in the diagnosis of cholecystitis. Chronic noncalculous cholecystitis is not a surgical disease. Cholecystitis with stones invariably requires surgical treatment, regard-



less of the symptoms and age of the patient, provided, of course, the patient's general condition will permit surgical intervention. Acute cholecystitis is primarily obstructive, rather than inflammatory. Operation within the first forty-eight hours is the treatment of choice. The question of whether cholecystostomy or cholecystectomy should be performed should be decided on the basis of the limitations of the surgeon and the patient. Early operation will save time and money, eliminate suffering and decrease the risk.

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## REGIONAL SEGMENTAL COLITIS

JORGE DE CASTRO BARBOSA, J ARNOLO BARGEN AND CLAUDE F DIXON

OBSERVATION, over long periods, of a large number of patients who had ulcerative colitis has led to the inevitable conclusion that, when the physician uses the term "ulcerative colitis," he is dealing, not with one disease entity, but with a large group of different disease entities behaving differently clinically and responding to diverse forms of therapy. Many of these entities have known causes, such as tuberculous, amebic, lymphogranulomatous, allergic or streptococcal colitis, they appear as a late phase of bacillary dysentery or are consequent to

TABLE 1—LIST OF INFLAMMATORY LESIONS OF THE BOWEL  
CLASSIFIED ACCORDING TO LOCATION

- I Large bowel
  - A Generalized colitis (involvement of the entire colon)
    - 1 Examples of known causes
      - a Streptococcal
      - b Late result of bacillary dysentery
      - c Allergic
      - d Cryptogenic
  - B Localized or regional (migratory or progressive) colitis
    - 1 Single region involved
    - 2 Multiple regions involved
- II Small bowel
  - A Generalized enteritis (involvement of entire or large portion of small bowel)
    - 1 Jejuno ileitis
  - B Localized or regional enteritis
    - 1 Jejunitis
    - 2 Ileitis
      - a Example regional ileitis
- III Small and large bowel (enterocolitis)
  - A Ileocolitis (one continuous lesion from terminal part of ileum into cecum and ascending colon)
    - 1 Example tuberculosis of the ileocecal region
  - B Colitis with ileitis or jejunitis or both (two separate lesions occurring concomitantly with normal bowel between them)

food or vitamin deficiency. There are, however, types of ulcerative colitis, the causes of which are unknown, for that reason they are generally grouped together under the same heading and discussed under the unfortunate term "idiopathic." The experiences gained from observation of a large number of these cases of cryptogenic colitis have convinced us that, even in this group, there exists probably more than one type of disease, judging from their clinical behavior and response to medical and surgical management.

Among these cases of cryptogenic colitis there is a relatively small

group that follows a similar pattern and the designation of regional or segmental colitis seems suitable. This is merely a descriptive term expressing the lesser degree of extension. Table 1 lists some of the inflammatory lesions of the intestines classified according to their location. In this way the group of cases to be discussed in this paper can be defined more precisely.

#### CLASSIFICATION OF THE VARIOUS TYPES OF COLITIS

In the first main group (table 1) are included those inflammatory lesions involving only the large bowel. They are generalized when the lesions involve the entire colon as well as the rectum. In this group



Fig. 407. Marled changes of segmental ulcerative colitis of the transverse colon near the hepatic flexure. This is a relatively short segmental involvement.

either the lesion stops abruptly at the ileocecal valve or else there is only a backflow involvement of the terminal ileum but no chronic inflammatory process characteristic of ileitis. There are several forms of known cause: those due to streptococci (colitis gravis or thrombo-ulcerative colitis formerly called idiopathic or nonspecific) to food or vitamin deficiency, to late bacillary dysentery and possibly to

allergy. There are forms of generalized colitis without known cause or causes which we have designated as cryptogenic. We suspect that there may be several forms of colitis, at present classified as cryptogenic that will eventually be separated from this group.

In certain cases the inflammatory lesion does not involve the whole colon. It is known that in amebic colitis the lesions are generally found in the cecum and that venereal lymphogranuloma generally involves the rectum, sigmoid and anus.



Fig. 408. Ulcerative colitis involving a long segment of colon from the hepatic flexure to the mid descending colon.

In the form of ulcerative colitis in which there is segmental involvement of the colon, those segments involved by the pathologic process are not within reach of the proctosigmoidoscope although their distal end can occasionally be visualized, hence the diagnosis can be definitely made only by roentgenologic examination of the colon. Generally only one small (fig. 407) or large (fig. 408) segment of colon is involved with a single continuous lesion but occasionally multiple involvement is observed, that is two or more segments separately involved with normal bowel between the lesions. Crohn and Berg<sup>10</sup>

described similar cases in 1938 under the denomination of "right sided colitis," since the terminal portion of the large bowel is found normal at proctoscopic examination and since in a large percentage of cases the right side of the colon is involved. They stated that the terminal ileum is almost invariably involved. We have not included such cases in this paper. In fact, in our series, any case in which there was significant involvement of the ileum was discarded, to be placed in a



fig. 409—Segmental ulcerative colitis of the left side of the colon. The roentgenogram shows marked narrowing and shortening of the distal half of the transverse colon, the splenic flexure and the descending colon down to the sigmoid. Proctosigmoidoscopic examination in this case showed 24 cm. of normal mucous membrane.

separate group classified under the heading of enterocolitis, which probably includes the majority of Crohn and Berg's cases. In 1930 Bargaen and Weber<sup>1</sup> presented data on a small group of cases under the heading of regional migratory chronic ulcerative colitis. Regional colitis seems to be the simplest and most descriptive term. The term "right-sided colitis" would not include all cases of regional colitis. There are cases in which there is segmental involvement of the left side of the colon (fig. 409). When the involvement is, however, in the

right side of the colon, either the lesion stops abruptly at the ileocecal valve or else there may be occasionally a retrograde involvement of the terminal ileum but again no characteristic lesion of terminal ileitis.

For the sake of comparison and completeness we included as our second main group in the classification, those inflammatory lesions confined solely to the small bowel (enteritis). Again, the involvement may be generalized in the entire small bowel or a very large portion of it (jejuno ileitis), as a continuous lesion or with intervening normal segments, or the involvement may be localized or regional in the jejunum (jejunitis) or more commonly, in the ileum (ileitis). In this group the great majority of the lesions are located in the terminal portion of the ileum and stop abruptly at the ileocecal juncture, hence the name "terminal ileitis." Except for a few isolated cases in which the cause is suspected to be tuberculosis, the cause of these lesions of the small bowel is completely unknown. It is doubtful whether avitaminosis is a causative factor. There is no positive and final evidence for an explanation on an allergic basis.

Our third main group includes inflammatory lesions involving simultaneously the small and the large bowel, these we group under the heading of enterocolitis. The lesion, however, may be one continuous process, from the terminal ileum into the cecum and ascending colon (ileocolitis), or else two or more separate lesions may exist concomitantly in the small and the large bowel but with a normal segment of bowel in between the ileum and the colon. Thus, there may exist colitis with ileitis or jejunitis or both. In the group of cases of ileocolitis there are characteristic pathologic changes in both colon and terminal ileum and not just backflow inflammation of the terminal portion of the ileum. This group includes all the granulomatous lesions of the ileocecal region, of which tuberculosis is an example. There is a large group of cases of ileocolitis of a hyperplastic nature, the cause of which is unknown, and other nongranulomatous lesions the cause of which is likewise unknown, many such lesions invade far down into the ascending colon. The second group—cases of enterocolitis—differs in that there are merely two concomitant lesions, one in the colon and the other in the small intestine, separated by a short or long segment of normal bowel. Segmental inflammatory lesions of the colon so far have not been found to behave in the unpredictable manner of ileitis after surgical treatment. The patient usually remains well when resection is extensive enough.

#### DEFINITION OF REGIONAL COLITIS

The term 'regional colitis' therefore refers to a nonspecific or cryptogenic inflammatory ulcerative or hyperplastic lesion involving one or more short or long segments of large bowel as one continuous lesion or as a multiple involvement of the colon sparing, however, its terminal portion. Either the proctoscopic examination does not reveal

any lesion in the terminal bowel for the whole distance observed, that is, approximately 24 cm, as in the majority of the cases, or at least the rectum is completely free from any involvement. No case in which there was any slight pathologic change in the rectum at the time of the first examination is included in this study. The terminal ileum likewise, in the vast majority of the cases, either is completely free from any pathologic change or else has merely a retrograde involvement, evidently secondary to the main colonic lesion.

### INCIDENCE

In an attempt to determine the frequency with which regional colitis occurs in comparison with the more commonly found types of colitis, namely, generalized ulcerative colitis, in which there are definite and

TABLE 2—AGE AND SEX IN CASES OF REGIONAL COLITIS

Age Years	Total Patients		Males	Females
	Number	Per Cent		
0-9	1	0.7	1	0
10-19	13	9.3	8	5
20-29	50	35.7	28	22
30-39	33	23.6	10	23
40-49	20	14.3	10	10
50-59	18	12.8	10	8
60-69	4	2.9	2	2
70-79	1	0.7	1	0
Total cases	140	100	70	70
Mean age	34.5 yrs		34 yrs	35 yrs
Youngest patient	3 yrs (Male)			
Oldest patient	73 yrs (Male)			

typical proctoscopic findings, we made a fairly complete survey of the total number of cases of all types of ulcerative colitis observed at the Mayo Clinic from 1923 to 1943, inclusive.

Approximately 4,000 different cases of ulcerative colitis (of the type under 1 A, table 1) were observed at the clinic during these years. During that time 140 cases of regional colitis, approximately 4 per cent of the total number were observed. The greatest number of these cases were observed in the last decade.

**Age and Sex.**—Table 2 shows that in our series the disease was equally distributed among male and female patients and that it occurred most frequently in the third and fourth decades of life. It can, however, affect persons of any age. Our youngest patient was three years of age and the oldest seventy-three; both were male.

### ETIOLOGY

Up to the present time the nature of regional colitis is unknown. All studies aiming to determine the cause of this interesting colonic lesion have terminated either with negative or with dubious results. In thirty-four of our 140 cases the question of tuberculosis was investigated. In one case the P.P.D. reaction for tuberculosis was positive first strength. In one case, after removal of a hyperplastic lesion involving cecum, ascending colon, hepatic flexure and portion of transverse colon, the pathologist made a diagnosis of multiple tuberculous ulcers on the specimen. In another case the pathologist made a diagnosis of tuberculosis, this time on two lymph nodes removed for biopsy at exploration.

In one case very many acid-fast bacilli were present in the stools in 1925. They were not definitely classified as *Mycobacterium tuberculosis* and none were found on repeated subsequent examinations. In 1944, nineteen years later, the patient wrote saying that he had never felt better and referred to nephrectomy that had been performed, not mentioning the cause. In one case in 1937 there were acid-fast bacilli in the stools, atypical for tuberculosis. The patient was reported dead in 1938. In one case in which the patient was reported dead one year after first being seen at the clinic tuberculous enteritis was said to have been observed at necropsy performed elsewhere. No convincing evidence, however, was reported. In all the rest of the cases the results of all tests requested were reported as negative. In one case the Flexner reaction for *Proteus* was reported in a dilution of 1:320 and in another, positive agglutination (Flexner) was said to have been found elsewhere. Stool examinations for ova and parasites and stool cultures were carried out in practically all of the cases and the results of these were consistently reported as negative. In one of our cases in which ileosigmoidostomy and subtotal colectomy were performed recently, the pathologist reported intestinal sarcoidosis (sarcoid of Boeck).

Ralphs<sup>1</sup> suggested an interesting pathogenesis for the chronic inflammatory "tumors" of the gastro-intestinal tract; a lesion in the mucosa, for example, a crack, fissure or superficial ulceration, would account for a portal of entry of an infection of slow and low virulence, provoking a chronic inflammatory reaction with round cell infiltration and mural infiltration. Adhesions of the infiltrated and thickened serosa to parietes, adjacent organs or neighboring loops of gut would develop or there would be retroperitoneal invasion by way of the mesocolon via lymphatics. The inflammatory mass of nonuniform tex-



ture and with small abscesses in its midst would show new granulation tissue, evidence of new infection together with zones of older granulation tissue with cicatrization that could provoke stenosis. Ralphs attributed the presence of giant cells of the foreign body type in the colonic lesions to foreign bodies or chemical compounds which provoked chronic irritation. This hypothesis might explain the inflammatory tumors or granulomas but would hardly explain the type of inflammatory lesions to which we refer.

Kirschner and Nordman, quoted by Ralphs, referred to the chronic inflammatory tumors of the cecum arising from chronic fibroplastic inflammation of the appendix and also to involvement and infiltration of the colon by direct extension of an inflammatory process from neighboring organs, for example, adneval disease invading the sigmoid flexure. This could well be the case when there are two lesions, one in the small bowel and the other in the colon. The lesion in the small bowel would be the primary lesion, invasion of neighboring organs is more characteristic of lesions in this location than of those in the colon. This may have been the sequence of events in one of our cases in which there were two concomitant lesions, one of jejuno ileitis and the other in the descending colon and sigmoid. In favor of this hypothesis are the results from surgical procedures directed to cure the lesion of the small bowel which go as far as to promote healing of the colonic lesions without any further surgical intervention. However, this hypothesis again would not explain our group of cases in practically all of which the lesion is an inflammatory process situated only in the colon with no other diseased organ in the abdominal cavity. The presence of giant cells in the sections has frequently led to the erroneous diagnosis of tuberculosis. Bacteriologic examination of the feces, inoculations of guinea pigs and rabbits and tissue cultures have persistently yielded uninformative data as to cause.

More profound studies of the allergic reactions of the viscera may throw some light on the pathogenesis of some of these intestinal lesions. Disturbed function of the visceral sympathetic nervous system from anaphylactic or anaphylactoid shock produced by heterogenic proteins, polypeptides, bacterial toxins, alkaloids and so forth can produce serious complications in different viscera, including the bowels. Convincing experimental data on the "Shwartzman-Sanarelli" phenomenon in animals and strong clinical evidence of visceral infarcts in man without any arterial or venous obstruction show that serious changes in several organs can be explained on the basis of vasomotor reflexes.<sup>2</sup> It is easy to imagine the rich intestinal bacterial flora causing a secondary infection of an infarcted segment of large or small bowel possibly with intravascular coagulated blood due to endothelial changes causing thrombosis in the capillaries. The experimental focal thrombotic phenomenon of the digestive tract caused by anaphylactic shock may correspond to the stippling frequently encountered in

segments of bowel near the obviously inflammatory lesions. A more rich and more virulent intestinal flora in the terminal ileum would explain this more frequent location of regional enteritis. The same would hold true for the large bowel.

#### LOCATION

Our knowledge of the extent of the involvement was based on roentgenologic data alone for the cases in which treatment was medical, on additional operative findings for the cases in which exploration was performed and on diagnosis by a pathologist of the resected specimens. In almost every case the roentgenologic examination gave precise indications of the extent of the disease. In a few cases the lesions, when seen at exploration, were more extensive than the roentgenologic findings would indicate. In some cases the additional involvement found at operation could not be demonstrated roentgenographically. We refer to the "stippled" areas on the serosal surface of the colon. In our opinion these areas of "stippling" are highly significant and we regard them as an indication of initial lesions of early involvement of the bowel by the inflammatory process. Resection or anastomosis should be carried out beyond these areas in order to guard against postoperative recurrence.

For the study of the extent of involvement at the first examination at the Mayo Clinic we classified the colon into small segments, namely, cecum, proximal and distal portions of the ascending colon, proximal and distal limbs of the hepatic flexure, proximal and distal halves of the transverse colon, proximal and distal limbs of the splenic flexure, proximal and distal portions of the descending colon, proximal and distal portions of the sigmoid colon and finally the rectum which was invariably free of disease at the first examination. We were unable to establish either a constant or even a more frequent pattern of involved regions nor were we able to make any kind of classification as to the form of distribution of the lesions, so varied was the manner in which the inflammatory process spread throughout the different segments of the colon. Instead, we calculated how many times each of the fourteen segments mentioned was involved, taking into consideration all the 140 cases. This revealed an average of approximately seven segments involved for each case.

The segments of the right half of the colon were by far more frequently involved than those on the left, hence the suggested term "right sided colitis" previously mentioned. However, the transverse colon was slightly more commonly involved than the ascending colon. The proximal segments of the left colon were commonly involved. The frequency of involvement decreased toward the distal portion of the left colon. In twenty-two cases the proximal sigmoid and in five cases the distal sigmoid was found to be involved and in some of these cases proctoscopic examination revealed the distal end of the inflam-

matory process. The terminal ileum in twenty five (18 per cent) of the 140 cases had some involvement evidently secondary to the main colonic lesion. In three cases there were concomitant lesions of the small and the large bowel separated by normal bowel. In the vast majority of the cases the colon was involved by a single short or long continuous inflammatory process at times with more marked changes in certain segments but in four cases there were two separate colonic lesions with normal bowel in between and in one case there was a patchy distribution of the inflammatory process.

#### PATHOLOGY

The lesions in the generalized and in the regional types of ulcerative colitis appear to be similar. One finds diffuse surface ulceration of the mucosa and denuded areas. Later in the course of the disease one finds polypoid hyperplasia, suppuration of the submucosa, thickening and induration of all the coats of the intestinal wall and chronic infiltration and scarring of the peritoneal serosa. Although grossly the woody inflammatory process of regional terminal ileitis may differ from the lesions of colitis, microscopically one finds the same nonspecific, chronic granulomatous, inflammatory process. The pathologic study alone does not give much information about the cause of these treacherous inflammatory lesions of the intestines. All the lesions seem to be of an infectious origin. The end result in different cases, that is the inflammatory reaction may be similar, granulomatous for the small bowel and ulcerative and hyperplastic for the colon but the primary infection may well be different.

#### SYMPTOMATOLOGY

The clinical course of patients who have the regional or segmental type of ulcerative colitis may be bizarre and varied. A patient may be in good physical condition and the symptoms may consist mainly of abdominal cramps sometimes severe accompanied by an occasional loose stool only occasionally associated with blood. On the other hand the patient's troubles may begin as an acute illness with evidence of toxemia, fever and great bodily depletion. In between these two extremes may be observed a great variety of clinical pictures that some times do not even give suspicion of the presence of colitis. It would be impossible therefore to give any precise description of the average clinical picture.

The diarrhea is rarely severe. The bowel movements in twenty four hours in many cases are not much more than three or four. They never reach the surprising frequency of the generalized forms of ulcerative colitis. The rectal discharges are never as characteristic as in generalized thrombo ulcerative colitis. There is little if any, pus. It is fairly frequent to find cases without any bloody discharge at all or

else with only streaks of blood. Patients who have this type of colitis have less urgency for bowel movements than those who have rectal involvement and the diarrhea is more often intermittent. Cramps are a common symptom and in some cases present themselves with a severity entirely out of proportion to the patient's physical appearance and to the clinical course of the disease. Cramps are situated along the line of the colon and may be relieved by a bowel movement. They also come intermittently, more often than in generalized colitis.

The fever varies according to the severity of the disease. In some cases the patients are afebrile or have low temperature. When fever is present it may vary anywhere from 101° to 104° F.

Loss of weight is a common feature of the disease. It may be moderate but at times it is very striking. Patients may lose from 20 to 40 pounds (9 to 18 kg) in a relatively short time. The weight can be recovered during the therapeutic or spontaneous remissions. This does not happen as often with wide extension of the disease in the colon as in other cases. Recovery of weight is slow when the disease has spread to the proximity of the terminal portions of the colon.

Although gross hemorrhages are rare, these patients present themselves with anemia of varied intensity, sometimes necessitating multiple transfusions, especially in those cases in which there are extensive involvement and very low concentration of hemoglobin. The differential count is, as a rule, insignificant, the leukocyte count does not reach high figures. The sedimentation rate is a good guide to the activity of the disease.

When there is a concomitant lesion of the small bowel it may dominate the picture or at least contribute to a great extent to the array of symptoms. The diarrhea may not be augmented because of the lesion of the small bowel but the cramps may be more severe. This is especially true in those cases of ileocolitis in which typical extensive granulomatous lesions occur in the terminal ileum continuous with the hyperplastic cecum and lesions of the ascending colon. The inflammatory process of the terminal ileum frequently causes stenosis, which might account for the severe cramps. In those cases in which there are combined ileitis and colitis but a normal segment of bowel between the lesions, the concomitant lesion of the small bowel may contribute most to the general emaciation of the patient. There have been cases in which the colonic lesion, if not anatomically cured at least remained quiescent after the removal of the lesion of the small bowel. One must, however, keep an eye on the colonic lesion and plan to perform its removal at the slightest provocation.

#### COMPLICATIONS

Secondary polypoid hyperplasia ending abruptly with the colonic lesion is commonly observed late in the evolution of the disease. Apparently, malignant change is not a complication or at any rate is a

rare one. There was one case of malignant change in this series. Gross hemorrhages are rare. Although the lumen of the colon is diminished in diameter, real formation of the stricture enough to cause acute obstruction is rare. The more common location of these inflammatory lesions in the segments of the right half of the colon, with larger diameter and more liquid stools may account for the infrequency of obstructing strictures. In one of our cases in which the disease spread



Fig. 410—Injection of barium and subsequently of air into the rectum under roentgenoscopic control revealed ulcerative colitis involving the left half of the transverse colon the splenic flexure and the upper half of the descending colon. Secondary polypoid changes can be seen in both limbs of the splenic flexure. A narrow segment of diseased bowel can be seen by transparency through a superimposed segment of colon. This is another example of the disease in the left half of the colon.

to the descending colon roentgenologic examination revealed a definite stricture, which was strongly suggestive of a malignant lesion. Exploration proved it to be of an inflammatory, cicatrizing nature. Rectal complications such as perirectal abscesses and anal fistula and suppurative condylomas are fairly frequently encountered, although proctoscopic examination reveals a normal bowel sometimes for the whole distance examined. If there happens to be such a lesion, one

should be cautious about any surgical intervention before controlling the disease in the intestine proximal to the rectum. Only such essential surgical measures as drainage of an abscess or control of anal discomfort should be carried out. Operations performed on perirectal infections and anal fistulas have met with disastrous results under such circumstances.

Other complications generally enumerated as characteristic of generalized ulcerative colitis, such as certain systemic manifestations, for



Fig. 411.—Severe and extensive ulcerative colitis beginning abruptly in the ascending colon and ending almost as abruptly at the juncture of the descending colon and the sigmoid. There is considerable shortening and narrowing of the colon with a marked secondary polypoid change.

example, arthritis, erythema nodosum, neuritis, infection of the urinary tract, phlebitis and, late in the disease, deficiency states, have been encountered with less frequency. Complications at a distance, such as in the skin and buccal mucosa, are almost unknown. The major complication in this type of colitis is perforation, which fortunately happens only rarely. It is generally chronic and the perforating lesion is promptly walled off.

## DIAGNOSIS

In this form of colitis we depend practically entirely on the roentgenologic examination of the large bowel, which in certain instances should be made by the double contrast method that is retrograde injection of barium and subsequently of air into the rectum (fig 410) always under roentgenoscopic control. In this way the fuzzy, distorted outline of the diseased colon is readily visible. Narrowing, hyperirritability, shortening and loss of haustration in a segment of bowel with negative findings in the bowel at proctosigmoidoscopic



FIG. 412. Chronic ulcerative colitis most marked in the transverse colon. However there is definite involvement of the descending and ascending colon to a lesser degree.

examination are diagnostic of segmental colitis. With the retrograde barium enema one can very well, in a great percentage of cases examine the terminal ileum. Occasionally one has to resort to the barium meal in order to detect lesions in the terminal portions of the ileum not visualized with the retrograde injection of barium. As a rule the roentgenologic appearance of the lesion is typical (figs 411, 412 and 413). It should be differentiated from that of carcinoma, occasionally this differentiation can present difficulties especially when a very short segment of colon is involved.

## CLINICAL DATA

The clinical data of our patients who have regional colitis and the comparative evaluation of results obtained from the different forms of treatment, medical or surgical, are of particular interest. Of the 140 patients ninety were treated medically, forty-three surgically and seven for reasons beyond our control, had no form of treatment of any kind. Medical treatment included rest in bed with all the supportive treatment available—intravenous administration of fluids blood transfusions, low residue (nonroughage), high protein diets and



Fig 413—Segmental involvement of the colon by ulcerative colitis from cecum to mid transverse colon. This is the most common type of involvement.

vitamin supplements. In sixty-two cases, in addition to the foregoing program, some form of chemotherapy with a sulfonamide compound was instituted at some time during the course of treatment. Classification into smaller groups according to the sulfonamide compounds used proved to be useless, so great was the variety of sulfonamide compounds used as the years went by and new compounds became available. In twenty-eight cases no sulfonamide drug of any kind was used at any time during the course of treatment.

Of the forty-three patients who underwent some form of surgical



intervention, eleven were treated medically prior to surgical treatment, six with the use of sulfonamide compounds and five without the use of this type of drug. These patients were included in the two groups that only had medical management for the period before surgical treatment was instituted. Table 3 shows the incidence of recurrence in each of the aforementioned groups followed for periods of one, two and three years. We use the word "recurrence" here for lack of a better word. "Relapse" could have served just as well. By "recurrence" we mean return of symptoms, with or without further involvement of other portions of bowel previously uninvolved. One immediately

TABLE 3—THE INCIDENCE OF RECURRENCE OF REGIONAL COLITIS ACCORDING TO TYPE OF TREATMENT FOLLOWING DIAGNOSIS AT THE CLINIC

Time Since Treatment	Medical Treatment		Surgical Treatment
	Sulfonamides	No Sulfonamides	
0-1 yr Patients traced Recurrence	58 31 (53%*)	29 8 (28%)	32 6 (19%)
1-2 yrs Patients traced Recurrence	39 24 (62%)	24 8 (33%)	28 7 (25%)
3 yrs Patients traced Recurrence	24 14 (58%)	19 8 (42%)	22 6 (27%)
Total patients in study	68†	33†	40

\* Percentages are based on patients traced in each group.

† Eleven of the patients who received medical treatment were subsequently treated surgically.

takes for granted that there was a period of remission of symptoms before the "recurrence" took place but we also included under this heading not only return of symptoms but recrudescence of symptoms and failure to bring about anchorage of symptoms under medical care.

A glance at the figures in table 3 reveals the high incidence of recurrence in all the groups. In more than half of the cases symptoms recurred within one year of observation after the diagnosis was made and these recurrences repeated themselves in the subsequent years. Recurrences were least frequent in the surgical group, and we must

point out that in this group dealt with here as a whole we included all cases whether the results were good or bad without regard to the surgical procedure

The figures shown in table 3 led us to another survey of the records in order to determine whether the groups were comparable. As criteria for comparability, we took into consideration the average extent of involvement for each group. Again we classified the colon into fourteen small segments and determined how many times each segment was involved, taking into consideration all the patients of

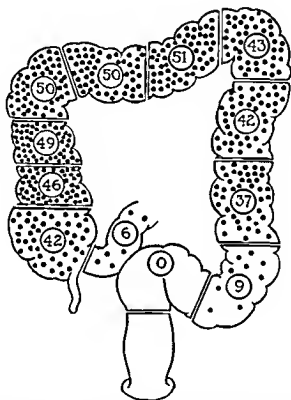


Fig 414—Segmental incidence of involvement in the sixty-eight cases in which treatment was medical with the use of sulfonamides. The numbers (number of black dots) represent the number of times each of the segments was involved.

each group, thus we found an average of eight regions involved for each patient treated medically with the use of sulfonamide compounds, six regions involved for each patient treated medically without the use of sulfonamide compounds and six regions involved for each of the patients treated surgically. There were more extensively involved patients in the first group than in the second and third. Considering however that each of the fourteen segments into which we classified the colon is relatively small there is not much difference as far as extent of involvement is concerned among the groups compared. The figures shown in table 3 differed for each group significantly enough

to overshadow any difference that may have existed regarding extent of involvement.

Figures 414, 415 and 416 show graphically the regional incidence of involvement for each group. The colon in these figures is classified into twelve segments, for the sake of simplicity, instead of fourteen; the hepatic and splenic flexures are each represented as one single region, since the incidence of involvement of the proximal and distal limbs was practically identical. The numbers (total number of black dots) represent the number of times each of the segments shown was

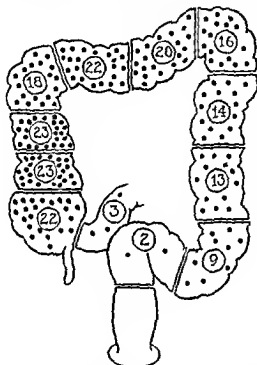


Fig. 415.—Segmental incidence of involvement in the thirty-three cases in which treatment was medical without the use of sulfonamides. The numbers (number of black dots) represent the number of times each of the segments was involved.

involved. The averages were calculated taking into consideration four segments of colon. In all the three groups the higher incidence of involvement for the right side of the colon than for the left is evident. There is minimal incidence of involvement in the sigmoid and the rectum is invariably uninvolved at the first examination.

The numbers in table 3 take into consideration merely the fact of recurrence regardless of the number of times it took place or its seriousness. Although the results from surgical treatment were by far the best as shown by the smallest percentages of recurrence in table 3, one has to take into consideration the risk of the surgical management.

which at times involves formidable procedures, especially if resection is to be undertaken. Among our forty three cases in which surgical treatment was used there were three operative deaths bringing the mortality rate to 7 per cent. Although this mortality rate is relatively low for this type of surgery, we thought it advisable to carry on further our comparative evaluation of results for the three groups of cases, taking into consideration frequency and severity of recurrences. Many patients with this disease, followed for a fairly long period have trouble consistently, frequently and seriously enough to warrant surgical treatment.

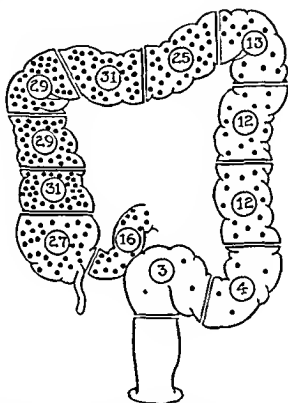


Fig. 416—Segmental incidence of involvement in the forty three cases in which treatment was surgical. The numbers (number of black dots) represent the number of times each of the segments was involved.

Table 4 shows the frequency of known recurrences for each group with follow-ups of one, two and three years. Here again the highest percentages of recurrence are for the first group, where the frequency of recurrences increases as the years go by, within two years a third of the patients had had multiple recurrences. Lower figures are encountered in the second group and still lower for the surgical group, except for the incidence of multiple recurrences in the three year follow up, where we find a relatively high figure of 18 per cent. The reason for this will be clarified when we consider the type of surgical procedure performed.

In order to evaluate the severity, we graded the recurrences from one to three. Those cases in which recurrence consisted only of significant clinical symptoms without further involvement of the colon were graded 1. When the clinical symptoms were very severe or resulted in further extension of the disease into other portions of the colon, previously uninvolved, the recurrence was graded 2. Finally, we graded the recurrence 3 when the disease extended to the terminal portions of the colon including the rectum, thus precluding further radical (resection) or conservative (sidetracking) surgical treatment leaving ileostomy as the only alternative (table 5). The longer the

TABLE 4—FREQUENCY OF KNOWN RECURRENCES FOLLOWING TREATMENT FOR REGIONAL COLITIS

Time Since Treatment	Medical Treatment Only		Surgical Treatment
	Sulfonamides	No Sulfonamides	
0-1 yr			
Patients traced	58	29	32
1 recurrence	48.0%	24.1%	19.0%
Multiple recurrences	5.0%	3.0%	0
1-2 yrs			
Patients traced	39	24	28
1 recurrence	28.0%	25.0%	18.0%
Multiple recurrences	33.0%	8.0%	7.0%
2-3 yrs			
Patients traced	24	19	22
1 recurrence	21.0%	37.0%	9.0%
2 recurrences	17.0%	0	5.0%
3 recurrences	17.0%	5.0%	14.0%
More than 3 recurrences	4.0%	0	0
Total of multiple recurrences†	38%	5%	18%

\* Percentages are based on numbers of patients traced in each group

† Six recurrences (one case)

‡ For patients traced two to three years

follow up of the patients the more severe are the recurrences. Within three years 21 per cent of the patients of the first group had recurrences that resulted in extension of the lesion into other portions of the colon; in 17 per cent of the cases the process extended as far as the rectum where positive findings were evidenced at proctoscopic examination. The figures for the more severe recurrences are lower for the second group than for the first, for the one, two and three year follow up.

Table 5 shows that the grade 3 recurrence was the highest among the surgical cases for all the three year follow ups. The type of sur

gical procedure, however, is not taken into consideration. Among the forty three surgical cases there were four simple explorations in which nothing was thought advisable surgically because of the extent of the involvement. In one other case, ileostomy was all that could be performed. In one case the only surgical measure was the closure of a stoma resulting from appendicostomy performed before the patient came to the clinic. In twenty cases a sidetracking operation (ileocolostomy or ileosigmoidostomy) was carried out as the only procedure in some resection was planned at a later date. Only fourteen patients had the benefit of resection of the diseased segment of bowel.

TABLE 5—SEVERITY OF KNOWN RECURRENCES OF REGIONAL COLITIS FOLLOWING TREATMENT

Time Since Treatment	Medical Treatment		Surgical Treatment
	Sulfonamides	No Sulfonamides	
0-1 yr			
Patients traced	38	29	32
Severity of recurrence			
Grade 1	34%*	17%	6%
Grade 2	12%	7%	6%
Grade 3	5%	3%	6%
1-2 yrs			
Patients traced	39	24	28
Severity of recurrence			
Grade 1	36%	12%	7%
Grade 2	15%	12%	4%
Grade 3	10%	8%	14%
2-3 yrs			
Patients traced	21	19	22
Severity of recurrence			
Grade 1	21%	26%	9%
Grade 2	21%	11%	
Grade 3	17%	5%	18%

\* Percentages are based on number of patients traced in each group

Table 6 shows the one-year follow-up results according to the surgical procedures, sidetracking or resection. One sees that all the recurrences were among those patients that had a sidetracking operation only, whereas there was no recurrence when a resection was undertaken, removing all of the diseased bowel. Table 6 shows the one-year follow-up only but the same results were verified by follow ups for two and three years. The numbers for the follow-ups for two and three years were too small to be included in the table. At the end of two years, in four of the thirteen cases of sidetracking in which the patient was traced there were recurrences, in none of the ten cases of

resection in which the patient was traced had there been any trouble. At the end of three years, in four of the twelve cases of sidetracking in which the patient was traced there were recurrences, in the seven

TABLE 6 REGIONAL COLITIS FOLLOW-UP RESULTS  
ACCORDING TO SURGICAL PROCEDURE

0-1 Yr	Surgical Procedure	
	Sidetracking Operation Only	Resection 1 or More Stages
Total cases	20	14
Patients traced	16	11
Recurrence	5 31%	0

cases of resection in which the patient was traced, there still was no case of recurrence. A fifty-four year old man, on whom cecostigmoidostomy was performed remained well for thirteen years, at the end

TABLE 7—FREQUENCY AND SEVERITY OF RECURRENCES  
OF REGIONAL COLITIS FOLLOWING SIDETRACKING OPERATION ONLY

	Interval After Operation		
	0-1 Yr	1-2 Yrs	2-3 Yrs
Patients traced	16	13	12
Frequency of recurrence			
1 recurrence	31%	15%	17%
Multiple recurrences		15%	17%
Severity of recurrence			
Grade 1	12%	8%	17%
Grade 2	6%	8%	
Grade 3	12%	15%	17%

\* Percentages based on number of patients traced for each time interval

of which time he was found to have arteriosclerosis and was a bad risk for resection. He had a very severe recurrence fourteen years after operation and died of intestinal hemorrhage fifteen years after the sidetracking operation. Three patients who had undergone sidetracking

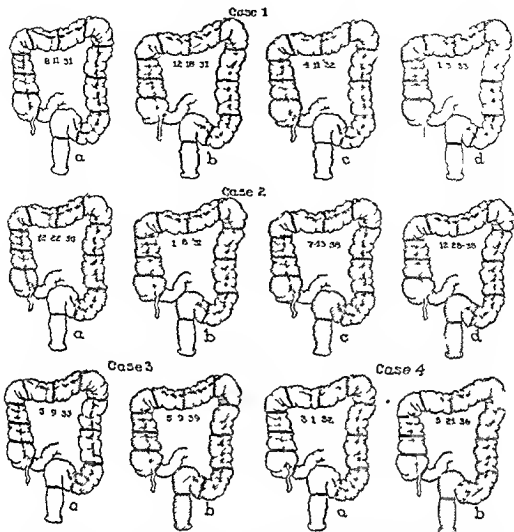


Fig. 417—Clinical course of three patients treated medically for regional sigmoid colitis without the use of sulfonamide compounds. The different parts of the figure represent involvement on the respective dates on which the roentgenologic examinations were made. In case 1 at the first roentgenologic examination (a) the only abnormal region observed was one of marked irritability at the junction of the ascending colon and the hepatic flexure. Only four months after this (b) the colon and the terminal ileum had become involved. In c the lesion had spread to the descending colon but in d the examination did not reveal any lesion in the descending colon. In case 2 the process which originally (a) involved the colon from the cecum to the proximal portion of the sigmoid, extended to involve the distal portion of the sigmoid (b), the rectum (c) and the terminal ileum (d). In case 3 there were two separate regions of involvement at the first roentgenologic examination (a). Extension took place both distally and orally at both regions. The rectum was eventually involved (b). In case 4 the original involvement from mid transverse colon to the sigmoid (a) extended to include the rectum (b).

were well eight seven and five years after operation. Two patients who had undergone resection were well five years after operation. Although the number of cases is small, we can make the statement that,



as far as we can tell, in none of the cases in which resection was performed was a recurrence observed for follow up periods of one two and three years

Table 7 shows the incidence of recurrence, taking into consideration both frequency and severity, following sidetracking operation only with follow up of one, two and three years. In 17 per cent of the cases in which sidetracking operation only had been performed there were multiple recurrences. In the same percentage of cases the severity

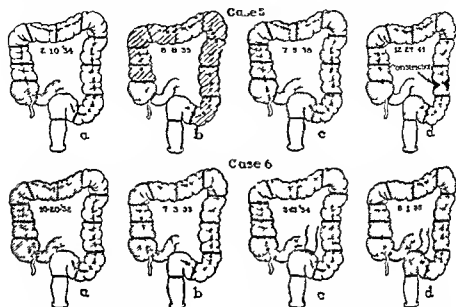


Fig 418—Clinical course of two patients treated surgically for regional segmental colitis. In case 5 roentgenologic examination (a) the cecum and the terminal ileum were involved. In b there is slight mucosal abnormality throughout the entire colon above the rectum and sigmoid. In c there are definite ulcerative changes throughout the colon. In d a constricting lesion has developed in the descending colon. This patient died eighteen days after extraperitoneal resection of the constricted region. In case 6 notice in a, b and c the gradual extension of the process from October 20, 1932 to March 21, 1934 at which time ileosigmoidostomy was performed. In d notice the involvement of the sigmoid and of the anastomosed terminal ileum. This shows the inadequacy and danger of the sidetracking operation alone.

of the recurrence was grade 3 (on a grading basis of 1 to 3 in which 1 represents the mildest and 3 the most severe). In order to demonstrate the development of colitis in these cases in a more colorful way we chose examples from each one of the groups and represented the evolution of the disease showing the spread of the lesion with the aid of diagrams (figs 417, 418 and 419).

The patients in cases 1, 2, 3 and 4 of figure 417 were treated medically without the use of sulfonamide compounds.

In case 1 on August 11 1931 there was an area of marked irritability of the colon at the junction of the ascending colon and hepatic flexure. Four months later the roentgenologic examination of the colon revealed extensive chronic ulcerative ileocolitis diffusely involving the terminal ileum cecum ascending colon and transverse colon. Four months after that the lesion had spread to the descending colon. Eight months after that, apparently, the extent of involvement was not so great, since the roentgenologic examination did not reveal any lesion in the descending colon.

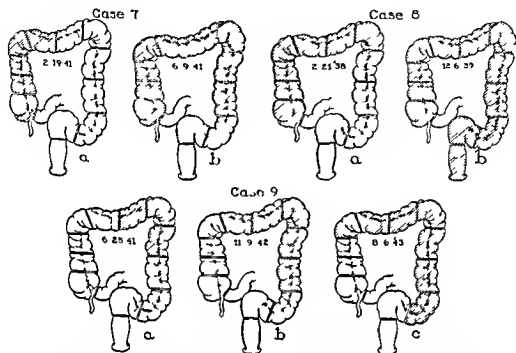


Fig 419—Clinical course of three patients treated medically with the use of sulfonamide compounds. In case 7 at the first roentgenologic examination (a) the right side of the colon was involved. Notice the marked extension of the process in b, less than four months later. Sulfaguanidine was the drug used in this case. In case 8 at the first examination (a) the colon above and including the splenic flexure was involved. The extension of the lesion to include the descending colon the sigmoid and the rectum as shown in b, took place in less than two years after the initial examination. Neoprontosil was used in December 1939. No sulfonamide compound had been used previously. In case 9 a b and c, show the oral and aboral spread of a lesion originally confined to the segment of the colon between the mid transverse and the mid descending portions. In this case sulfaguanidine sulfathiazole and succinylsulfathiazole had been used.

In case 2, the process on December 22, 1930 was already very extensive there was diffuse extensive ulcerative colitis involving the entire colon proximal to the rectum the bowel was normal for a distance of 24 cm at proctoscopic examination. By January 8 1931 the process had spread to the upper third of the rectum where a proctoscopic examination revealed an ulcerated moth eaten mucosa. After this there seemed to be a long period of remission but by July 13 1938 ulcerative colitis involved the entire colon with marked deformity of the cecum although there seemed to be very little shortening of the bowel as noted by roentgenologic examination. Proctoscopic examination at this time

showed ulcerative colitis of the whole rectum. The terminal ileum was reported as normal. In December of the same year that is five months later the lesion had spread to the terminal ileum which by roentgenologic examination was found to be involved as far as visualized with the barium enema. We were informed that this patient in February 1939 apparently had a perforation that terminated her life.

This case illustrates the importance of a long follow up study for one to realize what might happen to these patients. After a lull of more than seven years in the course of her disease, this patient had a recurrence with a fatal outcome.

In case 3, the roentgenologic examination of the colon on March 9 1933, revealed two regions of ulcerative colitis with secondary hyperplastic changes in the mucosa one in the distal transverse colon including the splenic flexure and another in the proximal sigmoid. The ileocecal region was uninvolved. At proctoscopic examination nothing was found abnormal in the bowel for a distance of 30 to 35 cm. Six years later there was involvement of the entire colon with marked shortening and deformity. A proctoscopic examination revealed chronic ulcerative colitis.

In six of fourteen cases in which the rectum was eventually involved subsequent to the first examination at the clinic, findings of chronic ulcerative colitis were evidenced at proctosigmoidoscopic examination one year after the first examination in four cases, three years in one and six years in the last. In five other cases inflammatory changes occurred in the rectum one, two, five and six years later, respectively.

The primary location and manner of spread of the lesions in generalized thrombo ulcerative colitis or colitis gravis are different from those in the regional or segmental type of colitis. In the former the initial lesion of the primary infection is in the rectum and the extension takes place proximally toward the cecum. In the latter the initial lesion can be located anywhere in the colon but is most often in the segments of the right colon although the spread of the disease can take place in both directions, orally and aborally, the more important spread is distal toward the rectum.

The highest incidence of location of the lesion, as seen in the combined cases from figures 414, 415 and 416 is found in the transverse colon. Since in our cases the disease was relatively advanced the transverse colon would be then the common pathway for the distal and proximal spread. In extremely few, if any, of the 140 cases had the disease been diagnosed prior to admission of the patients to the clinic, even among the more recent cases. There was no way in which we could trace back cases of generalized colitis in order to see whether in any of them the disease had been regional or segmental at the start. The suspicion however, exists that cases of typical generalized colitis were previously cases of segmental colitis. Cases of advanced ileocolitis could have been originally cases of regional colitis with eventual ex-

tensive ileal involvement. In cases 7, 8 and 9 of figure 419 treatment was medical with the use of some sulfonamide compound. In case 7 on February 19, 1941, ulcerative colitis involved the cecum, the ascending colon and the oral half of the transverse colon. In four months the lesion had spread throughout the colon from the ileocecal valve to the sigmoid. In case 8 extensive ulcerative colitis, involving the colon above and including the splenic flexure, had spread distally and involved the whole colon in less than two years. Case 9 is a good example of spread of the disease in the two directions, distal and proximal from an initial lesion involving the splenic flexure and part of the transverse and descending colon.

In case 5 of figure 418 the disease was diagnosed as an irritable bowel syndrome in 1929. In February, 1934, roentgenologic examination of the colon revealed changes in the cecum and terminal ileum suggesting involvement of the type seen in anebiasis but the clinical pathologists did not find parasites or *Mycobacterium tuberculosis* in the stools. The rectum and sigmoid were also free of any lesion. By August, 1935, another roentgenologic examination showed slight mucosal abnormality throughout the entire colon, suggesting early or minimal inflammatory changes consistent with ulcerative colitis. The rectum and sigmoid remained clear. By July, 1938, although the most marked changes were noted in the right half of the colon, there were definite ulcerative changes throughout the whole colon. In December, 1941, secondary polypoid hyperplasia and an inflammatory constricting lesion in the descending colon were noted. In June, 1942 the patient was still having much trouble and since it could not be definitely determined that the constriction was the result of inflammation surgical exploration was undertaken and an extraperitoneal resection of the constricted region was performed; the patient died of generalized peritonitis eighteen days later.

Of the other two patients who died after operation among the forty three patients of the surgical group, one had ulcerative colitis involving the cecum as far as the splenic flexure and last few inches of the terminal ileum. Resection in one stage was undertaken: a portion of the terminal ileum, cecum ascending and transverse colon being removed, continuity of the intestinal tract was reestablished by side to side ileosigmoidostomy with proximal stab wound colostomy. The patient died twelve days after operation of bronchopneumonia and generalized peritonitis.

The third operative death occurred abruptly in a case of ulcerative colitis with secondary polypoid change from the ascending colon to the juncture of the descending and sigmoid colon. Neoprontol was tried without result for two months at the end of which time ileosigmoidostomy was performed with consequent death of the patient from peritonitis twelve days after operation.

We must point out that none of the three patients had the benefit of preoperative chemotherapeutic intestinal antisepsis. They were all operated on before the general use of succinylsulfathiazole.

Among the surgical patients eight died at a later date and from other causes than colitis. One patient felt well for two and a half years after ileosigmoidostomy up to the time when further trouble indicated the advisability of further exploration which revealed generalized carcinomatosis. One patient died from unknown cause one year after cecoesigmoidostomy. One patient had ulcerative colitis of the trans-

verse and descending colon, ileosigmoidostomy was successfully performed elsewhere and the patient remained well for thirteen years. A bad recurrence of the disease took place during the fourteenth post operative year. One patient underwent removal of the cecum ascending, transverse and descending colon and a portion of the sigmoid colon with retrograde sigmoidal enstomy. Seven months after this operation the patient died from intestinal obstruction and peritonitis after an operation performed elsewhere. According to the surgeon's report the operation was performed too late, because of the patient's refusal of immediate surgical intervention. In two cases in which resection would have to be too extensive because of simultaneous lesions of the small bowel exploration was all that was done. The patients had clinical recurrence one year after operation and died two years after operation from unknown causes. One patient was reported dead from cerebral hemorrhage five years after resection of the ascending colon and a portion of the transverse colon.

#### THERAPEUTIC SUGGESTIONS

As a result of our clinical experiences with patients who had this form of colitis our statistical analysis and the detailed follow up study of this group of patients over a period of twenty years, we venture the following suggestions for the treatment of these patients. Nearly all of them should have the advantage of some form of medical treatment. Such a program of medical treatment should include a satisfactory rest program and an adequate diet, which should be high in proteins and vitamins and low in residue. Various supportive measures should be included in the program of treatment. Blood transfusions are commonly advisable. During the acute phase of the trouble one of the sulfonamide compounds should be given. Succinylsulfathiazole seems to be the one of choice. Tables 3, 4 and 5 might be taken to indicate that the sulfonamide compounds did not serve any important purpose in the management of these patients. This would be an erroneous conclusion for while they may not have been a real factor in the ultimate cure of these patients there is evidence to show that they were of material benefit in the control of the active infectious phase of the disease. They were important in reducing the active infection thus greatly reducing the surgical risk associated with the removal of the segments of diseased bowel. Furthermore in many instances they were a prominent factor in helping the patient through an acute attack of the disease.

In some cases the medical regimen resulted in the complete relief of symptoms and objective signs of the disease. Sulfaguanidine and succinylsulfathiazole were administered to several patients in the series over protracted periods and in a few cases roentgenologic examinations of the bowel ultimately showed complete absence of objective signs of the disease. Since however in several cases recurrences came be-

tween three and fifteen years after complete relief of all symptoms and signs, it is difficult to speak of any cure short of surgical treatment.

Because of the high incidence of recurrence and the unpredictable manner in which this disease behaves, radical surgical excision seems to be the treatment of choice. The cases in which patients were followed up over long periods suggest that the danger of recurrence after surgical treatment is minimal and very much less than the recurrence following the resection of segments of the small bowel for regional ileitis. The important consideration is the choice of the best time for the resection and the proper and careful rehabilitation of all these patients before surgical treatment is undertaken. Although excellent results were obtained in a few cases by the sidetracking operations such as ileocolostomy and ileosigmoidostomy, recurrence in the cases in which these operations alone had been performed was so frequent that the physician should not be too confident about the temporary good results obtained from the sidetracking operations alone. The colonic lesion apparently does not heal merely by the sidetracking procedure. Our experiences with these cases would seem to justify the conclusions that all these patients should receive an adequate medical regimen, that resection is probably the treatment of choice, that the time of such resection must be carefully determined by the clinician and the surgeon working together, that adequate preoperative management is of the greatest importance and that short-circuiting operations do not yield final good results.

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# CONSIDERATIONS IN SURGICAL TREATMENT OF SEVERAL COMMON ANORECTAL ABNORMALITIES

NEWTON D. SMITH

NUMEROUS discussions describing the surgical technique employed in correcting anorectal lesions have been published. I would not attempt to discuss some of the surgical problems and variations from other viewpoints might be of greater assistance than merely to discuss the diagnosis and treatment of internal and external hemorrhoids, anal fissure and fistula in ano. Perhaps for a change it may prove assistance to discuss some of the peculiar phases of these problems and to offer practical suggestions. The notorious tendency for fistula in ano to recur after operation, the frequent observation of an unsatisfactory result from an inadequate hemorrhoidectomy and the fact that a fourth of all the anal fissures observed at the Clinic have been treated previously seem to justify the presentation of a discussion such as this.

To introduce this discussion it is necessary that several important preoperative factors be recalled. The history of the patient's disability should be obtained and evaluated. It is advisable to attempt to learn of any of the patient's peculiarities such as the tendency toward prolonged bleeding or to respond abnormally to common medicinal agents such as morphine sulfate. Such knowledge will often aid in making a convalescence smooth which otherwise might be very stormy. The patient also should have a thorough gentle sigmoidoscopic examination prior to anorectal surgical treatment.

In discussing the operation with the patient reasonable or tactful frankness concerning the anticipated discomfort should be the rule and the common tendency to belittle an anorectal operation should be avoided. There is little doubt that the shrug of the shoulder and the accompanying "Oh There's nothing to it!" do no good and frequently do harm to the patient's attitude. It seems helpful to explain simply some of the reasons for the discomforts or disabilities. A few minutes of friendly counsel, even when the surgeon is pressed for time will often save time in caring for the patient after the operation as well as avoid many hours of worry on the patient's part. Left to his own thinking the patient is prone to build a disturbing structure of apprehension but with assurance and explanation prior to the operation an attitude can be fostered which will make him feel that because others have done it he can too.

Let us consider a practical example of the attitude which can be fostered. During the consultation the patient can be informed that he may have a somewhat unpleasant passing his urine. This is further explained by



telling him that normally in voiding his urine he relaxes his anal tens on which may be present and that he then strains by contracting the diaphragm and abdominal muscles. After the operation he will find that it will be difficult to relax the anal musculature and that any attempt to strain will cause some anal discomfort. These variations from normal may prevent him from voiding urine readily but, it will be explained, usually this difficulty will correct itself. Furthermore it may be possible for him to get out of bed or go to the bathroom. A trial of this sort of surgeon-patient relationship will soon convince the most dubious surgeon of its value. It need not be carried to the point of being a nuisance but this reasonable sort of explanation helps the patient to feel that he is a member of a partnership which is working for his welfare rather than the ignored victim of a series of unfortunate and uncomfortable events.

The patient who has had one or more operations frequently offers a special problem which will tax the patience and kindness of the surgeon or the physician who may only attempt to examine the anorectal region. Under such circumstances the patient will often exhibit almost insurmountable apprehension. If the surgeon moves slowly and gently, warning the patient of each move, he may develop the confidence of the patient who then not only will be grateful but may be able to co-operate satisfactorily. It seems wise to encourage rather than to urge impatiently any person who, having had previous anorectal surgical treatment, requires further examination or additional surgical treatment.

Ordinarily hospitalization of the patient prior to any anorectal operation is brief, providing only sufficient time for suitable preparation or physical examination if it has not been accomplished in the physician's office. The preoperative preparation should be so carefully outlined to those who will carry it out that all mishaps may be avoided especially careless or needlessly rough enemas. To the hospital staff this may seem but a routine matter, however to the patient about to have an anorectal operation any roughness may forecast needless post-operative discomfort.

At the time of the operation sacral or low spinal anesthesia will prove most satisfactory. The patient should be placed on his abdomen on the operating table and his hips should be elevated. His position will be satisfactory then because the anus may be exposed readily and the assistants as well as the surgeon may observe the progress of the operation being therefore of greater help.

There seems to be no limit to the enthusiastic desire for information concerning the surgical treatment of anorectal lesions especially internal and external hemorrhoids, anal fissure and fistula in ano. Frequently however it is desired that such information be given in numerical order—step by step. Many operations have been described in this manner but it seems almost too evident that if this were the

proper way to solve the problem, then there would be little reason for the enthusiastic curiosity that persists. The greater the familiarity with anorectal operations, the greater must be the realization that the lesions themselves vary from case to case, that the anal canal is not always the same length nor the muscles of equal volume. Continued observation reveals that pelvis vary, making anorectal operations easier or more difficult, that most frequently not one lesion but several lesions are present, that each successful operation results not from following a given description step by step but by understanding the problem and the objective and then accomplishing an operation which will attain that objective. It is true that many simplified procedures seem to accomplish satisfactory results. However, too frequently these results are temporary rather than permanent as planned.

The patient's reaction to anorectal treatment is peculiar and because of his eagerness for relief and his inability to evaluate properly immediately the result of the treatment his reaction is often misleading. Patients will boast enthusiastically when relating the experience and the results of patently insufficient treatment. They seem eager to prove the soundness of their judgment, as probably most of us are, and once having related the disability, the simplified treatment and the miraculous result, they become inexplicably reticent and will not retrace their steps, even reluctantly, to tell their former audience of the return of any of their anorectal trouble. Such an attitude, though it can be understood, leads to incorrect impressions, thus making difficult the task of evaluating various treatments accurately. There is no simple road to the solution of anorectal problems, but understanding some of the mechanical factors will help the surgeon to produce satisfactory permanent results.

The surgeon is compelled to provide his own standards. It seems reasonable that a satisfactory result is one in which pathologic tissue and other abnormalities are corrected, providing comfortable normal function with minimal deformity and as much permanence as is possible. It seems honest, too, to sacrifice a little time postoperatively, if necessary, to insure greater permanence.

Each of the lesions under consideration requires careful attention at the time of the anorectal examination but it does not seem satisfactory to try to plan the exact operation at that time. It will be observed that with the relaxation of the muscles resulting from the anesthesia any preconceived plan will require such extensive alteration that it will prove to have been almost wasted effort. Thinking of each operation as an individual problem would seem to stimulate variations of technic which may lead to procedures which will prove more satisfactory than those with which the surgeon has previously been content.

Fortunately nature has provided anatomic landmarks which act as ready guides during the operation and most of the anatomic structures are so superficially placed that they can be identified readily. Our

knowledge of the anatomy of the part is, or can be, so thorough that with a little extra effort we can promptly recognize individual variation as well as abnormality and, therefore, we can plan the operation which will solve the problem of each patient individually. A few of the factors which alter operative procedures and in which knowledge of the part will assist materially are scar tissue, contraction requiring dilatation, which then usually causes some edema and may cause abundant bleeding during the operation—a short anal canal may dilate easily but a longer canal may prove more difficult, hemorrhoids, which may be so extensive that satisfactory exposure may be difficult, several coexisting lesions frequently adding to the difficulty of the problem, the presence of some coexisting disease such as chronic ulcerative colitis which necessitates minimal surgical treatment, the presence of a sinus of questionable origin which may produce incontinence if improperly operated on. This list could be enlarged extensively but would not serve the purpose more satisfactorily.

Many facts which must be considered in performing anorectal operations seem apparent. All of the operations must be accomplished so as to permit ample drainage because of the inability to produce or maintain a sterile field postoperatively. It is hoped that chemotherapeutic agents will accomplish this unflinchingly some day but, until that day comes, leaving anorectal wounds open for drainage and planning the incisions so as to prevent overhanging edges prove consistently most satisfactory.

#### INFECTED ANAL CRYPT

The simplest example of a desirable sort of anal wound is the one generally accepted as classical for the drainage of an infected crypt. In this wound the incision is made (usually over a probe) from the

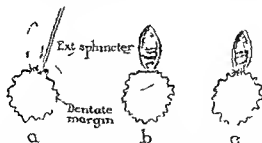


Fig 410—Cryptectomy *a* Probe in place for incision. Dotted line indicates additional excision of skin *b* Excision completed *c* Sutures placed to control bleeding or retraction of mucosa

orifice of the crypt to a point beyond the anal verge (fig 420, *a*) and the margins of this incision are then usually trimmed so as to provide free drainage (fig 420 *b*). The relationship of skin and mucous membrane (fig 420 *b*) is not altered appreciably. The wound is not sutured

closed. Muscle fibers are not incised and they form the base of the wound. Sometimes because of bleeding or retraction of the mucous membrane from the level of the dentate margin it is necessary to place one or two sutures (fig 420, *c*).

This is a simple operation essentially designed for the purpose of providing drainage and thus healing an infected crypt. However it illustrates amply the fundamental requirements of a satisfactory anorectal wound, ample for its purpose, the base is formed by the external sphincter muscle fibers and there is enough wound surface beyond the anal margin to insure sufficient drainage during the healing of the wound. Usually this operation is accomplished without timidity because the basic principles can be grasped readily.

#### ANAL FISSURE

A satisfactory excision of an anal fissure can produce a wound basically similar to that resulting from the incision of an infected crypt. Frequently an anal fissure is complicated by the presence of an enlarged papilla and an external tag, often there is also a small subcutaneous abscess or a tiny superficial sinus resulting from the surgical or spontaneous drainage of a preceding abscess. Frequently also the anus is contracted, necessitating dilatation. Logically the anus should be gently dilated first and then the fissure excised, occasionally it is necessary to incise through the base of the fissure superficial to the external anal sphincter muscle to accomplish the dilatation with minimal injury to the sphincter (fig 421, *a*).

Following the dilatation a Mayo Ochsner clamp may be employed to grasp the rectal mucous membrane in the anterior or posterior midline about 0.5 cm above the dentate margin. Just above (cephalad to) this clamp place a double tie of plain no. 1 catgut, having the ends each 10 to 12 inches (25 to 30 cm) long. Starting between the clamp and the double tied suture a curved incision may be made on either side of the fissure in normal anorectal tissue, mucous membrane and skin superficial to the external sphincter muscle and extending in the quadrant involved about 2.5 cm beyond the anal margin (fig 421, *a*). It may be necessary to dissect the base of the anal fissure carefully from the underlying muscle fibers. It is not possible always to avoid the muscle fibers entirely but a slight defect in the surface of muscle is not of great moment. Contrary to the advice frequently given, it is not necessary often to incise purposefully the sphincter fibers underlying the fissure. When the wound is completed the denuded area should appear nearly 3 cm in diameter, sometimes larger (fig 421, *b*).

The double-tied suture (fig 421, *b*) may be drawn externally toward the inner margin of the external sphincter, which is usually thinner posteriorly than anteriorly or laterally. The tied suture marks that portion of the mucous membrane which should be placed in the midline. A curved, saber-pointed needle should be placed on one of the

tion or anatomic peculiarities. The fixation of the boundaries may be accomplished by means of a variety of clamps or sutures and one method is illustrated here (fig 422, *a* and *b*). The manipulation of the tissue to be removed can be satisfactorily accomplished by means of Mayo-Ochsner clamps (fig 422, *a* and *b*). The simplest description of the landmarks which if used will insure thorough removal of the abnormal tissue is (a) the normal perianal skin beyond the lateral limit of the external hemorrhoid will form the lateral boundary of the wound, care being taken that it is sufficiently distant to insure ample drainage of the contemplated wound, (b) the normal mucous membrane above the cephalad margin of the internal hemorrhoid will form the superior or medial boundary of the wound (fig 422, *a* and *b*), (c) the base of the wound should consist essentially of the superficial fibers of the external sphincter muscle exposed as the hemorrhoid is removed (fig 422, *c*). The application of the suture to fix the level of

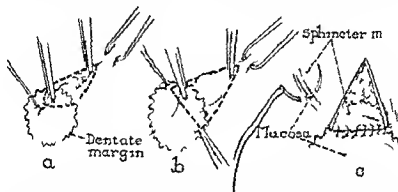


Fig 422.—Hemorrhoidectomy *a* and *b*, The dotted lines indicate area to be excised *c*, Completion of the excision Inset indicates method of suturing mucosa to proximal fibers of external sphincter

the distal margin of the mucous membrane at the level of the dentate margin can be accomplished satisfactorily by using the exposed proximal fibers of the medial margin of the external sphincter muscle as a fixed landmark and suturing the mucous membrane by means of a curved, saber-pointed needle and plain no 1 catgut (fig 422, *c*). A continuous locked suture or interrupted suture may be employed in the manner illustrated in figure 422, *c*. This will draw the mucosa distally and also prevent it from turning under.

In suturing the mucous membrane the surgeon takes advantage of its free mobility over the underlying tissue but it must be remembered that after the anesthesia disappears and the normal muscle tone of the part returns the tendency will be for the mucosa to retract rather than protrude. This tendency makes it possible that a suture of smaller diameter than plain no 1 catgut may tear through or that too great a distance between individual sutures may cause the mucosa to gape.

more widely than is apparent at the time that the suture is inserted, thus unnecessarily increasing any tendency there may be for the wound to bleed along the edge of the mucous membrane. The mobility of the mucous membrane may permit a small portion of the mucosal margin of the wound to be employed to suture to the entire proximal margin of the exposed external sphincter muscle, leaving a redundancy of mucosal margin without a satisfactory site at which to anchor it. Careful observation will obviously prevent such an embarrassing but easily corrected error.

At the time of suturing the mucosal edge to the external sphincter muscle it is advantageous to observe the cutaneous margin of the wound and to remove any tags even though they appear tiny. One should also remove any skin which may appear abnormally detached from the underlying tissue. It seems to be a normal tendency to be timid in the removal of the perianal skin at the time of anal operation but because of the marked tendency for skin tags to form and for excessive edema to involve any injured skin it is best to remove just a little too much rather than to leave a little too much. A good rule would seem to be "Leave as much normal tissue as possible but do not hesitate to remove enough skin to provide drainage and prevent the formation of skin tags and other undesirable deformities." It seems worthy of mention also that in many cases lateral traction by means of a tenaculum or manually in an effort to expose either side of the anus may rotate the external sphincter in such a way that when the traction is relaxed it will be found that the sphincter projects medially over the sutured mucosal margin. Such a deformity is undesirable and should be promptly corrected because it would encourage the formation of abscesses proximal and lateral to the body of the external sphincter muscle. This deformity may be avoided by relaxing the lateral traction momentarily before beginning the suturing and repeating this maneuver occasionally during the suturing if there seems to be any possibility of such an error.

The removal of each hemorrhoidal mass should be completed before starting to remove the next mass. If the hemorrhoids involve the entire anal margin it may be necessary to remove all of the perianal skin. This is permissible and advisable since the surgeon is usually faced with the alternative of removing all of the margin to remove all of the hemorrhoids or of removing only a portion of the margin and leaving a proportionate amount of hemorrhoidal tissue.

After the operation is completed and the single sponge removed it is advisable to place three sponges into the anus and withdraw them slowly as at the start of the operation and during the withdrawal to observe the wounds for bleeding and possible skin tags and to be sure that all of the hemorrhoidal tissue has been removed. It may again be observed that the wounds if properly formed resemble basically the incised infected crypt, varying essentially only in size or width and

the presence of the suture (fig 422, *c*) Perhaps it would be best to recall that my purpose is not to describe a rigid technic but one which may be altered by the surgeon if he will but try to produce basically sound wounds

#### FISTULA IN ANO

A fistula in ano originates in an infected anal crypt except in some female patients in whom the primary infection may occur at a point in the anterior midline midway between the dentate margin and the anal verge or in those comparatively rare cases in which a penetrating wound occurs in the perianal, anal or closely adjacent rectal surface. To the patient this lesion usually appears first as an abscess in the anal or perianal regions or above the dentate margin in the rectal wall. It is rare that the patient is conscious of the original injury which permits the invasion of infection into the anal and perianal tissue after which the abscess appears



Fig 423—Perianal abscess and incision. *a* indicates schematically the primary source of infection in an anal crypt the burrowing of the infection and formation of abscess. *b* is the abscess incision for drainage, *c* is method of elevating margin of incision to facilitate removal

The abscess should be permitted to become fluctuant before being incised to permit drainage (fig 423, *a*). Sometimes, if the abscess has been present for several weeks without becoming fluctuant, it may be assumed that the abscess is draining through the point of origin the primary opening, and under these circumstances the abscess may be incised (fig 423, *b*). The incision of an abscess may be accomplished without anesthesia if the abscess is superficial and very fluctuant. Peritotal sodium intravenous anesthesia is satisfactory for the incision of an abscess. The length of the incision will vary, depending on the size and location of the abscess, but the incision should be sufficient to permit free and ample drainage. The freedom of the drainage may be further insured if each edge of the incision is picked up by thumb forceps and removed with scissors, forming an elliptical opening (fig 423, *c*).

Having incised the abscess it seems advisable to inform the patient that he will probably have a fistula which will require further surgical

treatment and that this cannot be done at the time of the incision of the abscess because the risk would be greater, the likelihood of poor anal control would be increased and the amount of tissue which would have to be removed would be excessive. Actually waiting five to four teen days often permits the abscess cavity to shrink to such size that not one minute of the waiting time proves to be wasted. In some cases in which there is widespread uniform induration the fistula tract becomes more detectable as the induration subsides thus simplifying an otherwise difficult task.

It is not unusual to have a patient ask what a fistula is and the simplest answer that I know is that a tunnel exists from a tiny opening in the rectum to another opening outside or inside, depending on whether it is an external or an internal fistula (fig 424, *a*). The question 'What are you going to do to cure it?' can be answered simply by explaining that the surgical effort is to convert the tunnel into an

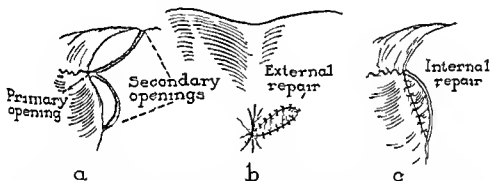


Fig 424—Fistulectomy *a* indicates both internal and external fistulas *b* is completed fistulectomy for the external portion of the fistula *c* is the same but for the internal fistula

open ditch. This is a very simple explanation and at the risk of seeming naive it appears to me to be a good explanation. Regardless of the complexity of the fistula, if this simple statement of purpose is adhered to by the surgeon during the operation many ambiguous situations will clarify themselves promptly.

Recalling the procedure employed in incising the infected crypt, we can start the fistulectomy in a similar way, by identifying the crypt (the primary opening), inserting a probe through the crypt and the fistula tract and then incising all of the tissue overlying the probe. If the fistula is external the overhanging edges of skin and subcutaneous fat then may be removed and the edge of the incised fistula tract sutured to the margin of the wound in the skin (fig 424, *b*). If the fistula is internal a probe is similarly passed through the tract and the tissue overlying the probe should be incised and a continuous lock suture placed through the base of the tract and the margin of the incision in the mucous membrane (fig 424, *c*). This is the description of



a simple fistulectomy to cure a simple fistula but it is surprising how simple many fistulas can be if the surgeon will keep this technic in mind. Sometimes it is difficult to pass the probe from the primary to the secondary opening but the probe may be passed from the secondary through the primary opening. There is no objection to this nor to the insertion of a different probe through each of the openings in those cases in which an angulation occurs in the direction of the tract preventing the insertion of the probe through the entire length of the tract. It is fundamental and imperative that the surgeon be certain that the probe is in the tract at all times before incising overlying tissue. If the situation of the probe is doubted it can frequently be decided satisfactorily by palpating the tract through the skin or mucous membrane, varying with internal or external fistulas, and then with the probe inserted into the tract only partially, the probe should be moved

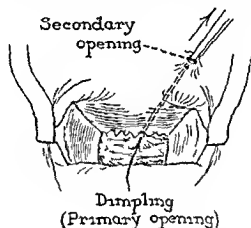


Fig. 425—Method of determining the primary opening of the fistula

up and down or from right to left. If the motion of the tract corresponds accurately in direction and distance with the motion of the probe it can be assumed that the probe is in the tract.

A bidigital examination of the anal and perianal tissue usually will provide more information than will the insertion of a probe in the effort to disclose the course of the tract. Such an examination has been described previously and consists in palpating the anal and the perianal tissue by inserting the index finger into the anus and by gently palpating all of the muscle, skin, subcutaneous fat, and so forth, intervening between this finger and the thumb of the same hand or the index finger of the other hand applied just outside the anus. A valuable method (fig. 425) of attempting to determine the primary opening of external fistulas is to expose the dentate margin in an area in which it is suspected the primary opening may be by means of an operating anoscope and then, grasping the lateral margin of the secondary open

ing in a Mayo Ochsner clamp, to "tug" it. At the instant of 'tugging' the secondary opening, the primary opening frequently will dimple, disclosing the site of origin of the fistula. Many rules have been suggested to simplify the task of discovering the primary opening of a fistula. At best these rules are hardly more than the result of analyses of typical cases and, while helpful, they prove misleading too frequently. If the surgeon can be certain that he has a probe in a fistula tract, twisting the probe or trying to make the wound agree with some rule will accomplish no good. If there are a number of subsidiary tracts the surgeon may uncover the basic tract and then the subsidiary tract but in some cases it will be found advisable to reverse this suggestion. The fistulous tract when incised will appear usually in such marked contrast to the normal tissue bordering it that the use of dye substance will prove unnecessary.

At the completion of the operation the wound may be dressed with gauze well saturated with white petrolatum and a soft gutta percha drain placed through the anus. The dressing should be removed in twenty four to forty-eight hours and a small soft cotton swab may be employed to prevent union of any overhanging margins by passing the swab along the base of the tract from the secondary to the primary opening. Another dressing of cotton partially saturated with a mild aqueous antiseptic solution may be placed in the wound gently but such a dressing should not be used as a pack since this would prevent the normal contraction of the margins of the wound and therefore it would unnecessarily encourage incontinence. The dressings should be changed daily or at frequent intervals until healing is almost or entirely completed. The postoperative care of anorectal wounds varies but fundamentally the effort should be to keep the wounds as mechanically clean as possible by irrigating them with mild nonirritating solution followed by the application of mild aqueous solution of nonirritating antiseptics. Heat or cold applied by means of hot or cold wet packs will help. It is also desirable that the patient be given a diet to provide a normal stool, except in some cases of extensive fistula.

Recalling the cryptectomy and recognizing the general acceptance of its soundness and the reasons for this acceptance and then following these similarities through the other wounds described may help to explain in a practical manner some of the reasons for planning anorectal wounds soundly. It is hoped that this discussion of some of the open types of anal surgical wounds may assist those physicians who are anxious to understand anorectal surgical problems.

a simple fistulectomy to cure a simple fistula but it is surprising how simple many fistulas can be if the surgeon will keep this technic in mind. Sometimes it is difficult to pass the probe from the primary to the secondary opening in the secondary this nor to the openings in those

cases in which an angulation occurs in the direction of the tract preventing the insertion of the probe through the entire length of the tract. It is fundamental and imperative that the surgeon be certain that the probe is in the tract at all times before incising overlying tissue. If the situation of the probe is doubted it can frequently be decided satisfactorily by palpating the tract through the skin or mucous membrane varying with internal or external fistulas and then with the probe inserted into the tract only partially, the probe should be moved

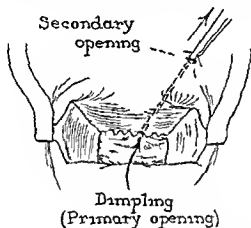


Fig. 425 Method of determining the primary opening of the fistula

up and down or from right to left. If the motion of the tract corresponds accurately in direction and distance with the motion of the probe it can be assumed that the probe is in the tract.

A bidigital examination of the anal and perianal tissue usually will provide more information than will the insertion of a probe in the effort to disclose the course of the tract. Such an examination has been described previously and consists in palpating the anal and the perianal tissue by inserting the index finger into the anus and by gently palpating all of the muscle skin subcutaneous fat and so forth intervening between this finger and the thumb of the same hand or the index finger of the other hand applied just outside the anus. A valuable method (fig. 425) of attempting to determine the primary opening of external fistulas is to expose the dentate margin in an area in which it is suspected the primary opening may be by means of an operating anoscope and then grasping the lateral margin of the secondary open

cedures certainly are a waste of time in cases in which the calculi are impacted. If the calculus is small and is causing no symptoms the patient may be kept under observation in the hope that the stone will pass provided infection or complete obstruction of the ureter does not intervene.

There are certain patients who definitely should be allowed to pass calculi under the observation and care of their physician. These are persons who have a urinary tract which does not respond well to manipulation. They react badly even to passage of an instrument through the urethra, and ureteral catheterization usually results in a long course of chills and fever. If these patients are known in advance then at least an attempt should be made to allow them to keep out of difficulty and pass their stones. This is not always possible.

The so-called medical treatment of ureteral calculi with various relaxing agents has failed in our hands. Many observers feel that these agents are of definite benefit. They apparently do no harm except in certain cases in which more prompt intervention might have been carried out with benefit to the patient. Some physicians do not believe in the use of morphine or other derivatives of opium, it being their contention that these drugs cause more spasm of the musculature of the ureter and thus tend to impede the passage of the calculus rather than to cause relaxation and more speedy expulsion from the meatus. Be that as it may, we are justified in our stand that relief from pain by the use of opiates should be continued. Certainly, anyone who has had ureteral colic will ask for all the medication possible if he is again subjected to this terrible pain.

Ureteral manipulation can be very simple or it can be one of the most difficult procedures the urologist is called on to perform. It is well known that the passage of a ureteral catheter may dislodge a calculus or change its axis so that the calculus can be engaged easily with instruments or will pass spontaneously.

The usual procedure is to attempt the passage of two no. 5 F ureteral catheters past the calculus to the renal pelvis. This attempt may be carried out under pentothal sodium anesthesia and frequently is successful. However, we feel that the pendulum is swinging back to low spinal anesthesia. Probably this produces more relaxation and results in less straining on the part of the patient.

If the two catheters pass the calculus with ease, it is wise to attempt to engage the calculus in one of the standard extractors. The catheters are removed first and then by use of the direct vision Braasch cystoscope the chosen extractor is passed gently through the ureteral meatus. The gentleness used in this procedure cannot be overemphasized. If trauma results the attempt at manipulation may end in failure or injury to the patient with at times, serious consequences.

The choice of the type of extractor will vary with the conditions present and the experience of the surgeon. The Councill extractor is

posterior abdominal wall toward the kidney and downward along the wall of the true pelvis. If a calculus is situated in the pelvic portion of the ureter it should, if possible, be displaced upward to a more accessible part to facilitate suturing of the incision in the ureter. However, this is easier said than done because calculi in the lower part of the ureter usually are removed *transurethrally*, but when *ureterolithotomy* is necessary it is because the calculus is impacted and *transurethral* manipulation has been unsuccessful. In such cases it is extremely difficult to displace the calculus in any direction. It often is unwise even to attempt displacing it because of the resultant *ureteritis* which makes the ureter extremely friable.

With the type of incision described almost all stones including those impacted at the *ureterovesical* juncture can be removed successfully. The incision in the ureter should be in the longitudinal axis and usually directly over the calculus. The calculus is removed gently, all precautions being taken to avoid fragmentation. The ureter then is explored by passing a *ureteral catheter* to make sure that it is patent throughout and that no other calculus is present. It rarely is necessary to leave a *ureteral catheter* in the ureter. However, when there is severe *ureteritis* it is unwise to attempt suturing of the ureter but is best to leave a no. 5 F *ureteral catheter* in the ureter. The catheter should extend from the renal pelvis into the bladder. If such a catheter is necessary it is best left in place for seven days at the end of which time it can be removed easily with the aid of the *cystoscope*. If the ureter is to be closed closure can be accomplished most easily as previously described. The operative field should be dusted lightly with crystals of *sulfathiazole* and a *Penrose drain* inserted to the depth of the wound. The *fascia*, *subcutaneous tissue* and *skin* then are accurately closed.

#### SUMMARY

In cases of *ureteral calculi* two things stand out: the simplicity and ease of *ureterolithotomy* in the upper two thirds of the ureter and the high proficiency of *transurethral* manipulation and removal of calculi in the lower part of the ureter. It seems unwise to temporize long in the hope that the calculus will pass spontaneously.

## VESICAL CALCULI IN WOMEN

DAVID S CRISTOL AND LAURENCE F GREENE

It is discouraging to realize that, although the study of vesical calculi forms one of the most ancient chapters in medical history the entire etiologic story is still a mystery. It is true, however, that the solution of the problem has progressed. Many etiologic factors have been proposed with reasonably good evidence. The part played by dietary deficiency or imbalance, racial proclivity, heredity, climate, endocrine disturbances, metabolic disorders, urinary stasis, infection and colloid crystalloid imbalance has been advanced. Likewise, great improvements have been made in the prophylaxis and in the medical and surgical treatment of urinary calculi. Although a logical explanation can be offered for the pathogenesis of many of the calculi, there remain many cases in which etiologic evidence is still wanting.

TABLE 1—NUMBER AND SIZE OF VESICAL CALCULI

Number of Stones	Instances*	Diameter of Stones, Cm	Instances*
1	51	0 to 1	14
2	7	1 to 2	13
3	2	2 to 3	23
4 or more	5	3 or more	15

\* Although the figures in this column total 65 only fifty nine cases were observed. In four of the cases stones were removed on two or more occasions.

Throughout the writings on this subject, one factor that has remained constant is the relatively infrequent incidence of vesical calculi in women. It is this curious fact which has given us the impetus to review a series of fifty-nine consecutive cases of vesical calculi in which the patients were females. In our experience at the Clinic we have found that approximately 4 per cent of patients who have vesical calculi are women. Crenshaw<sup>1</sup> reviewed 606 cases of vesical calculi and reported that in twenty-nine, or 4.78 per cent, the patients were women.

In our study, vesical calculi were encountered in females in all decades of life. The majority of the patients were between the ages of forty and seventy years. The most common urinary symptoms were urinary frequency, dysuria and gross hematuria. From table 1, which

relates the number and size of the vesical calculi it may be seen that a single calculus was present in most instances. Thus the age incidence, symptoms and characteristics of vesical calculi in women are similar to those reported to occur in men.

In considering the etiology of vesical calculi in the light of present day knowledge, one can only evaluate the contributing factors. Table 2 shows the pathologic conditions associated with vesical calculi in females. One examining this table is struck by the dominant role played by urinary stasis. An element of urinary stasis was found to be present in at least forty-three of the reported fifty-nine cases.

In twenty-six of the forty-three cases in which the calculi were associated with urinary stasis, a deformity of the bladder was apparent. The deformity was found to result from a variety of causes including congenital vesical diverticula, extravescical pressure secondary to large pelvic masses, postoperative scarring following repair of vesical fistula and operations on the pelvis. In fourteen of these twenty-six cases it is probable that the vesical calculus had its origin in the kidney and subsequently passed into the bladder. In these cases there was roentgenographic evidence of renal or ureteral calculi, or a history of typical renal colic, or both. Ordinarily, renal stones that pass into the bladder are easily evacuated by females. Undoubtedly, the deformity of the bladder impeded the expulsion of the calculus in this group.

Evidence of vesical fistula was present in eleven cases of the entire series of fifty-nine cases. Nine of the fistulas were of the vesicovaginal type while two were of the vesicoenteric type. At times the calculi formed at the site of the fistula and frequently were dumbbell in shape (fig. 426). In five instances the fistula had been successfully repaired and the calculi formed in sacculi present at the site of the repair. There was urinary stasis in the sacculi. Vesical calculi were present in six other cases in which surgical repair of the fistula had been unsuccessful. The factor of urinary stasis was considered not to be present in this group. In five of these cases a nidus in the form of a foreign body, such as a tip of a catheter or a wire suture, was inadvertently supplied at the time of the attempted surgical repair. No cause for the formation of the calculus could be determined in the remaining case.

Persistent urinary retention and infection were responsible for the formation of vesical calculi in seven cases. The patients had been hospitalized for conditions unrelated to the urinary tract and were free of urinary symptoms or findings prior to their admission to the hospital. During their convalescence after hysterectomy, confinement, scarlet fever or lobar pneumonia, urinary infection and retention developed and were followed by the formation of a vesical calculus. We believe that stasis of urine was the predominant cause for the formation of vesical calculi in this group.

The chief etiologic factor in six other cases was urethral obstruction

and obstruction of the vesical neck. Among the causes of the obstruction were urethral strictures, urethral tumors and hypertrophy of the vesical neck. In all but one of the cases, the obstruction of the urethra or vesical neck was associated with residual urine and urinary infection.

In two cases the patients had neurogenic vesical dysfunction which necessitated the use of an indwelling urethral catheter. When the patients came to the Clinic it was determined that there were calcareous crusts surrounding the catheter as well as discrete calculi lying



Fig. 4-6 Dumbbell vesical calculus at the site of repair of a vesicovaginal fistula.

free in the bladder. In these cases one may assume that the nuclei for the formation of a calculus originated from the incrustation associated with the catheter. The urinary stasis further facilitated the formation of the vesical calculi.

In two other cases, stones developed during a protracted period of immobilization because of an injury of bone. In these cases the factors which favored the formation of calculi included stasis secondary to impaired drainage and altered calcium metabolism secondary to the immobilization.



females than in males. The absence of the rigid posterior urethra or prostatic enlargement in the female facilitates the ease with which the stone can be engaged. However, the vesical deformity frequently found in females with vesical calculi sometimes increases the difficulty of this procedure. The presence of a dumbbell shaped calculus or a calculus lying within a diverticulum necessitates suprapubic removal. In such cases it is not only necessary to remove the calculus but also to repair the associated deformity.

#### COMMENT

This paper is based on a review of fifty-nine consecutive cases of vesical calculi in which the patients were women. We were impressed with the relative high incidence of vesical calculi in women who had had repair of a vesical fistula.

Many authors writing on the subject of vesical calculus believe that the majority of vesical calculi represent additional deposition about a calculous nucleus originating in the upper part of the urinary tract. Although most authors have stated that the relative incidence of calculi in the upper part of the urinary tract in men and women is in a ratio of 3:2, in many of the reported cases the number of men is only slightly greater than the number of women. The almost equal incidence of calculi in the upper part of the urinary tract is of interest when compared with the vesical calculi in the sexes. The relative incidence of vesical calculi in men and women is in a ratio of 17:1. The most logical reason why vesical calculi occur less frequently in women than in men is the comparative infrequency of obstruction of the vesical neck and urethra with resulting urinary stasis among women.

Thus one sees that the urinary stasis is by far the most common contributing factor in the formation of vesical calculi. This factor was definitely present in forty-three of the fifty-nine cases. It was considered to be absent in nine cases in which the calculus was found to be associated with a foreign body, in six cases in which there was evidence of stone in the upper part of the urinary tract and in one case in which repair of a vesical fistula had been unsuccessful.

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## ROENTGENOLOGIC LOCALIZATION OF THE PLACENTA (PLACENTOGRAPHY)

RAYMOND J. SCHEFTZ,\* C. ALLEN GOOD AND ARTHUR B. HUNT

THE not uncommon occurrence of painless vaginal bleeding in the last trimester of pregnancy may be indicative of such a serious obstetric complication that any harmless method which might aid in its differential diagnosis should be widely adopted. It is estimated that some degree of bleeding occurs in 3 to 5 per cent of all pregnancies during the final three months of gestation. In some cases the cause of the abnormal discharge is readily determined, in others, it may not be so obvious and under these circumstances roentgenologic localization of the placenta (placentography) may be of inestimable aid in planning the management. A presumptive clinical diagnosis of placenta previa may be substantiated or refuted by a roentgenographic technic capable of attaining an approximate accuracy of 90 per cent. The method which we shall describe is devoid of danger to either fetus or mother and may be carried out without special roentgenologic equipment. It may eliminate the necessity of an undesirable vaginal examination which might increase the possibility of renewed severe hemorrhage or infection.

We desire to review our experience with the method as employed on a relatively small obstetric service. The roentgenographic procedures have been standardized by numerous contributors since the method was first reported and excellent historical accounts have been given by Smith<sup>6</sup> and by McCort, Davidson and Walton.<sup>7</sup> Direct visualization of the placenta was originally announced by Snow and Powell<sup>8</sup> in 1934, and Ude, Weum and Uner<sup>12</sup> contributed the preliminary investigations on indirect placentography in the same year. During the past ten years, through the combined efforts of obstetricians and radiologists, the principles of interpretation have been well formulated so that today the procedure rests on a sound basis and has become a valuable adjunct to obstetric diagnosis.

### DIRECT PLACENTOGRAPHY

**Technic**—In order to attain the greatest possible degree of accuracy it is important that meticulous attention be given to all details so that roentgenograms of optimal diagnostic quality be obtained. No special preparation of the patient is necessary but it is preferable that the urinary bladder be emptied beforehand, also, in some cases it may be desirable, if feasible, that the patient take a small enema before the

\* Since this paper was written Dr. Scheftz has entered the armed forces. He is now a Lieutenant in the Medical Corps of the Army of the United States.

examination is undertaken. Fetal movement during the exposure may cause blurring of detail and be very annoying at times. It can be reduced to a minimum or entirely eliminated by instructing the patient to breathe deeply several times before each roentgenogram is made, this procedure insures adequate oxygenation for the fetus during the exposure when the patient should be holding her breath. Three 14 by 17 inch ( $35.6 \times 43.2$  cm.) roentgenograms of the abdomen are made: one anteroposterior view and two lateral views. One of the lateral views is made with lateral spine technic to show the posterior uterine wall and the other is made with 'soft tissue' technic to demonstrate the anterior wall of the uterus. Ball and Golden<sup>1</sup> recommended that roentgenograms be made with the patient in an upright position. In each case the film should be so placed as to include the desired structures. In all cases the uterine fundus should be included on the roentgenogram. These three views may be sufficient to localize the placenta satisfactorily; if not, indirect placentography must be utilized.

**Anatomic Consideration**—Direct visualization of the placenta is dependent upon the study of soft tissues as portrayed on the roentgenogram. In the last trimester of pregnancy the placenta occupies from a fourth to a third of the area of the uterine wall and is seen as a mass of soft tissue situated over a segment of the inner surface of the uterus. It is thickest at its midportion where its maximum measure is much as 5 to 6 cm., and tapers toward the periphery to blend with the uterine wall. The mature placenta is usually irregularly circular in shape but there are many possible variants. In the majority of cases the placenta lies ventral to the fetus and it frequently exhibits indentations caused by the small parts. It is often demarcated from the fetal structures by a black line of increased radiability attributable to the subcutaneous adipose tissue of the fetus. As a rule the placenta is found on the upper part of the uterine wall, either anteriorly or posteriorly, extending up to or over the fundus; it may extend somewhat onto one of the lateral walls. The progressive thinning of the uterine wall in the latter months of pregnancy renders direct roentgenographic visualization of the placenta possible as an apparent localized bulging or thickening of that wall and its actual expanse can often be determined. Torpin's<sup>10</sup> studies on the relationship of the uterus and placenta as determined by distention of the amniotic sac after its expulsion from the uterus have been a valuable contribution to the roentgenographic study of placental localization. He found that of a large series of placentas so studied the great majority were implanted on the relatively flat anterior or posterior wall of the uterus. In the few exceptions they were situated on the lateral wall directly over one of the uterine horns.

**Roentgenologic Interpretation**—From our experience with placentograms we have established that there are four possible roentgenologic diagnoses which might be considered in any particular case. These

possibilities and the findings upon which they are based will be discussed in detail

*Placenta Situated in Upper Uterine Segment*—Should direct placentography be performed in a consecutive series of pregnancies this would be, by far, the most common finding (probably 85 to 90 per



Fig 428—*a*, Placentogram showing thickening of the upper part of the posterior wall of the uterus due to the placenta which is implanted there, *b*, diagrammatic representation showing relation of uterine wall and placenta. Diagnosis confirmed at cesarean section (performed because of diabetes)

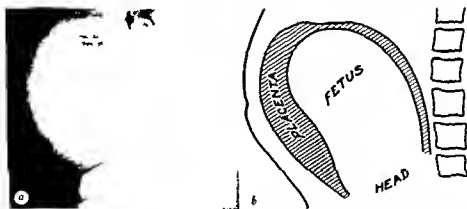


Fig 429—*a*, Placentogram showing anterior wall of the uterus thickened due to implantation of the placenta at that site, *b*, diagrammatic representation of relationship of placenta to wall of uterus. Diagnosis of normal implantation confirmed at delivery

cent of the total) The soft tissue shadow of the placenta can be directly visualized on either the anterior or posterior wall of the upper uterine segment. It extends to, or over, the fundus and its lower border is seen to stop well up on the uterine wall. Occasionally, it extends onto the lateral wall and rarely may be implanted almost entirely on

the lateral wall. As mentioned previously, the placenta is almost always situated ventral to the fetus. In studying this type of placenta the lateral roentgenograms will be most helpful (figs. 428 and 429).

*Low Implantation of Placenta*—Before proceeding farther it must be emphasized that a roentgenologic report of "low implantation of the placenta" as used herein is not necessarily synonymous with a similar diagnosis made by the obstetrician. We use the term with a qualifying statement and the difference will become apparent as the discussion progresses. In some instances, instead of the uppermost edge of the placenta being situated at or near the fundus, it is found to be a variable distance below this area, on the anterior or posterior wall. In a few cases it may be possible to determine the lower limit of the placenta, but in others it is impossible to be certain of this point. One reason for this is that, on the lateral roentgenogram placental soft tissue detail is not well defined in the lower uterine segment primarily because of the superimposition of the bony pelvis, the upper portions of the femurs, and the external soft tissues. This renders direct visualization of the lower portion of the placenta quite difficult. Again it must be appreciated that although various placentas are similar in many respects there exist enough differences in size, shape, and manner of attachment (for example, whether the long axis is vertical or horizontal) that it may be impossible to judge accurately the lower limit of any particular placenta which is seen to originate some distance below the uterine fundus.

It is possible to rely to some extent upon indirect signs in order to evaluate such a placentogram. In the anteroposterior roentgenogram the distance of the presenting part above the upper edge of the urinary bladder is noted. If there is no disproportion between the presenting part and the pelvis, and if the rectum is empty, the finding of a high-riding presenting part may be due to a low-lying placenta although other factors enter into the consideration. The soft tissue outline of the placenta can sometimes be seen interposed between the fetal head and urinary bladder in the anteroposterior view as originally described by Ude-Wesum and Urner.<sup>1</sup> In the lateral roentgenogram the distance between the symphysis and fetal head (presenting part),<sup>2</sup> and between the sacral promontory and fetal head are noted.<sup>3, 5</sup> It is impossible to give measurements as to the normal in such cases but after some experience one appreciates the normal relationship of these structures and becomes suspicious when one of these distances is so widened as to suggest the possibility of an interposed placental mass.

This type of placentogram with its inherent limitations in defining the lowermost edge of the placenta, is most difficult to interpret and the variety most subject to erroneous interpretation. Depending upon our analysis of the factors discussed, we have been in the habit of submitting one of three types of reports, as follows: (1) low implantation of placenta without evidence of placenta previa, (b) low im

plantation of placenta possible marginal placenta, (c) low implantation of placenta, probably placenta previa of some degree. In other words the many variants of placental size, shape, and manner of attachment render it necessary to consider many lowly implanted placentas as possible degrees of placenta previa. Our experience in this respect



Fig. 430—Placentogram showing placenta on anterior wall of uterus but its uppermost margin is some distance below the fundus. Diagnosis was low implantation of placenta on anterior wall of uterus possibly marginal placenta previa. At delivery patient was found to have a marginal placenta previa.

concur completely with that expressed by McCort, Davidson, and Walton.<sup>5</sup> In such a case it becomes necessary to examine the patient vaginally or, preferably, by indirect placentography, dependent of course on clinical considerations in a further effort to determine the placental site more accurately (fig. 430).

*Placental Shadow Not Definitely Seen*—On some placentograms it is impossible to distinguish a soft tissue shadow at any point on either uterine wall which might be interpreted as placental in nature. The total absence of a placental shadow in the upper uterine segment or in the uppermost portion of the lower uterine segment may be presumptive evidence of placenta previa; it is a diagnosis arrived at by exclusion. Occasionally, the outline of the placenta may be directly made out interposed between the presenting fetal head and the upper margin of the urinary bladder. Or, one may note indirect signs indicative of placenta previa, such as a "high-riding" presenting part, increased distance between the symphysis and the fetal head, or increased distance between the sacral promontory and the fetal head.

Conversely, the absence of any of these indirect signs may be evidence against a diagnosis of placenta previa. We have noted several placentograms wherein it was impossible to distinguish a placental shadow at the usual site, yet placenta previa was not present. Therefore, when a placenta cannot be distinguished on a particular placentogram, one of two possible roentgenographic interpretations may be given: (a) placental shadow not definitely seen, but no evidence of placenta previa; (b) placental shadow not definitely seen, probably placenta previa. As in the report of low implantation of placenta, so also here the next step demands vaginal examination or indirect placentography.

*Placental Localization Indeterminate*—It is generally agreed that the determination of the placental site is quite difficult, if not impossible, before the seventh month of pregnancy.<sup>3</sup> This is due to the relatively thick uterine wall with consequent poor demarcation from the as yet immature placental mass as shown on the roentgenogram. In general this is true but we have successfully demonstrated the placental site in a very few instances before the last trimester, as a rule, however, the attempt is not successful, although worth an effort when necessary.

In the presence of hydramnion the fetus appears enveloped in a diffuse haziness caused by the excess of amniotic fluid and since the placenta casts a similar type of shadow as the fluid, its situation can not be determined.<sup>7</sup> Other reasons for failure of direct placentography are (1) multiple pregnancy, (2) extreme obesity of the patient and (3) roentgenograms of poor diagnostic quality.

#### INDIRECT PLACENTOGRAPHY

*Technic*—Essentially, indirect placentography is performed by introducing some contrast material into the previously catheterized urinary bladder and then noting the character and magnitude of the distance between the upper margin of the bladder and the presenting fetal part as demonstrated on the roentgenogram. The method was first introduced by Ude, Weum and Urner,<sup>12</sup> and has received widespread attention. The technical considerations have been fully de-

scribed in the literature and it would seem unnecessary to restate them here. For contrast medium we have used both air and sodium iodide and are unable to express any preference but it should be mentioned that a remote possibility of embolism does exist when air is introduced into the bladder.

**Interpretation**—The principles of interpretation in direct placentography have also been well described especially by Ude and his co-workers.<sup>11, 12</sup> They stressed the importance of demonstrating a homogeneous tissue mass between the presenting part and the margin of the bladder. 'Normally this space consists of the wall of the lower uterine segment, the deflection of the peritoneum between the uterus



Fig. 431—*a* Placentogram made after catheterization and before instillation of contrast material in the bladder. a homogeneous soft tissue mass is seen interposed between the fetal skull and the upper margin of the bladder. *b* placentogram made with sodium iodide in bladder. the soft tissue mass is seen to be of larger than normal proportions. Diagnosis of central placenta previa was confirmed.

and the bladder, and the thickness of the bladder wall itself. The total diameter of these tissues is about 1 cm., and seldom exceeds this width on the roentgenogram. The central type of placenta previa practically always displaces the presenting part upward over the entire upper surface of the bladder, while the partial type shows a distinct tendency to depress one of the lateral horns of the bladder and displace the presenting part somewhat toward the opposite side.<sup>11</sup> Some authors hold the opinion that the method is valueless when any part of the fetus other than the head presents, others have used it successfully in the presence of breech or shoulder presentation (figs. 431 and 432).

An appreciable space between the presenting part and the bladder is not always conclusive evidence of placenta previa. A preceding



fetal hand, blood clots in the lower uterine segment, fecal distention of the rectum, disproportion between the presenting part and the pelvis, pelvic tumors, and possibly other conditions may cause an increase in the space between the bladder and the presenting part. Hall (Curry and Lynch)<sup>4</sup> and Beck and Light cautioned against the diagnosis of placenta previa unless the contour of the bladder shadow conforms to that of the fetal head, thus indicating transmitted pressure. The latter authors also stated that whenever the bladder is abnormally placed the possibility of this displacement being due to torsion of the uterus should be considered.



Fig. 432. Indirect placentogram made with instillation of air in the urinary bladder. There is a depression of the right lateral horn of the bladder and also a progressive widening of the distance between the fetal head and the upper margin of the urinary bladder toward the right. Marginal placenta previa found at delivery.

We believe that the lateral view, as recommended by Snow,<sup>7</sup> gives valuable information. It may be made by using a 14 by 17 inch (35.6 by 43.2 cm.) film with the long diameter at right angles to the patient. It is essentially a lateral view of the pelvis and the lower margin of the roentgenogram should include the ischial tuberosities. We have not used air insufflation of the rectum but believe that it might be of value in a case wherein the placenta is situated mainly on the posterior wall of the uterus, as pointed out by Snow and Rosensohn.<sup>8</sup> A placenta in this site is the most difficult to localize accurately.

## REVIEW OF NINETY SEVEN CASES

As mentioned previously, our experience with placentography has been somewhat limited but we have a series of ninety-seven cases available for study after excluding those in which sufficient data could not be obtained. In five of the ninety-seven cases, placental localization was indeterminate (because of fetal immaturity in three cases, because of hydramnion in one case and because of unsatisfactory roentgenograms in another case). Regarding the remaining ninety-two cases, it should be mentioned that not all of the patients were studied because of vaginal bleeding, since in the earlier days of this study placentog-

TABLE 1—ACCURACY OF PLACENTOGRAPHY IN NINETY-TWO CASES

Group	Cases	Placentographic Diagnosis		Findings at Delivery		Accuracy of Placentography in Respective Groups Per Cent
		Diagnosis	Cases	Findings	Cases	
1	72	Placenta implanted in upper uterine segment	7	Placenta implanted in upper uterine segment Placenta previa*	69 3†	96
2	14	Low implantation of placenta but no evidence of placenta previa	2	Low implantation of placenta	2	8
		Low implantation of placenta possibly marginal placenta previa	8	Low implantation of placenta Marginal placenta previa Partial placenta previa Premature separation of placenta	4 2 1 1†	
		Low implantation of placenta probably placenta previa of some degree	4	Marginal placenta previa Central placenta previa Low implantation of placenta	1 1 2†	
3	6	Placental shadow not definitely seen but no evidence of placenta previa	3	Normal implantation of placenta	3	100
		Placental shadow not definitely seen but probably some degree of placenta previa	3	Placenta previa*	3	
Total	97					93

\* Type of placenta previa was not specified.

† Placentographic diagnosis erroneous.

raphy was routinely carried out on patients referred to the roentgenologic department for a consideration of multiple pregnancy, fetal abnormality or abnormal presentation. This fact will explain the relatively large number of placentas found to be situated in the upper uterine segment. In the series of ninety-two cases the placenta was accurately located roentgenologically in eighty-six cases an accuracy of 93 per cent (table 1).

It will be noted that the poorest results were obtained in that group of patients found to have a "low implantation of the placenta." This difficulty and the reasons therefore were referred to previously. Occur-

sionally, it may seem that the roentgenologist is temporizing when he uses such terms as "low implantation of placenta, possibly marginal placenta previa," and "low implantation of placenta, probably some degree of placenta previa." It does not seem possible, however, to be more specific in many cases when direct placentography alone is utilized. In the fourteen cases reported as cases of various degrees of



Fig. 433 Placentogram showing apparent implantation of placenta in upper part of posterior wall of uterus. vaginal examination disclosed partial placenta previa

low implantation of the placenta, the patient was sent back for indirect placentography in only a few instances, and in each of these the placenta was accurately localized. We believe that had more of the patients been studied with contrast material in the bladder the degree of accuracy could have been materially increased. However, the decision as to further disposition of the patient in these cases must

rest with the attending obstetrician who is familiar with the clinical findings. The fact that the roentgenologist has been able to point out the possible existence of some degree of placenta previa may be all the information needed in many instances. Of the three errors in this group of cases, one was attributable to fetal immaturity (the period of gestation was six months and placental localization should not have been attempted).

The findings in the other two varieties of roentgenologic report can be seen by reference to table 1. It will be noted that there were three cases of placenta previa in which the roentgenologist had made a diagnosis of normal implantation of the placenta in the upper uterine segment. In one of these cases, placental localization should not have been attempted, again because of fetal immaturity.

In another case, marginal placenta previa was not recognized by indirect placentography, although review of the placentograms showed that the diagnosis could have been made. We have been entirely at loss to explain the findings in the third case. In this case the patient was a gravida III para II, aged twenty-eight years, who was referred for placentography because of intermittent painless vaginal bleeding during the seventh month of gestation. Her first pregnancy, which had occurred at the age of twenty years, had been complicated by retention of a large part of the placenta which subsequently had been removed manually. Her second pregnancy had been uneventful. After the onset of bleeding during her third pregnancy, placentograms taken in the seventh month showed thickening of the upper posterior uterine wall characteristic of that caused by placental tissue (fig. 433). The roentgenologist reported that the placenta was implanted on the upper part of the posterior wall of the uterus. The examination was repeated in the eighth month and gave identical findings.

Because the bleeding continued, vaginal examination was performed and a partial placenta previa was found. Obviously, the thickening of the upper part of the posterior wall of the uterus was not due to placental tissue but we cannot suggest what might have caused it. This is the only case in our series in which a definite thickening of a segment of the upper part of the wall of the uterus was not due to the implantation of a placenta at that site.

### CONCLUSIONS

Because placenta previa is a major obstetric accident which appreciably increases the maternal and fetal risk, accuracy in diagnosis must be as high as possible. The treatment depends on establishing definitely the type of placenta previa that exists. In case of doubt, vaginal examination should be performed under aseptic conditions and all preparations should be made for pelvic or abdominal delivery as indicated by the findings.

Our experience with placentography leads us to agree with the contention of other authors that the procedure is a valuable addition to

the field of obstetrics. Patients experiencing third trimester bleeding may be studied by direct placentography. If the placenta is seen to be situated in the upper part of the uterus placenta previa can be fairly confidently excluded as a factor in the bleeding. If the placenta is implanted low on the uterine wall or if no placental shadow is seen in the usual site placental localization may be deduced on the basis of indirect signs but corroboration with contrast material in the urinary bladder is highly desirable.

The method has its limitations which must be fully appreciated by those who would utilize it. It seems probable that the procedure is of little value before the seventh month of gestation. One of its greatest limitations however is the one which is dependent upon the variations in size, shape and manner of attachment of the human placenta. Taking all factors into consideration it would seem that the accuracy of the method should approximate 90 per cent. Because there is no maternal or fetal danger inherent in the procedure and since it can be so accurate roentgenologic localization of the placenta should be more widely employed.

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operation were much more serious than at the present time. The relative elimination of some of these risks has made possible certain massive surgical procedures which a quarter of a century ago had not even been contemplated, and have resulted in methods which though occasionally employed at that time, have become routine procedures.

Chief among the risks which have been rendered less important with the passage of time are those which are the result of blood loss and/or operative shock. Of slightly less importance were the risks of wound infection and more particularly spread of infectious processes. Finally, pulmonary complications including pneumonia were and to a lesser extent still are, causes of both morbidity and mortality among surgical patients.

To an increasing degree during the six war years the number of young persons in our hospital wards has gradually and continuously decreased. Since the wards have remained full it has become true that we are, in fact, practicing the surgery of geriatrics. The type of operative procedure indicated has become more massive since it has had to do with carcinoma, peripheral vascular disease and other surgery of the aged, the risk of operation has therefore, become more impressive and, despite the improvement in methods which have as their aim the combating of operative risk, the death rate following operation has gone up and the period of hospitalization has increased. This latter fact exists despite the marked decrease in hospital days in the usual types of major surgery.

Elsewhere in this symposium the subjects of cardiovascular disease, damaged kidney function and diabetes have received attention as they affect the operative risk. It is my purpose here to consider briefly other aspects of the subject which are of most importance to the surgeon and consequently to the person who is about to submit to operation.

The risks to which the person subjected to operation may be exposed fall into the classification which follows. This list does not attempt to arrange the risks in order of either frequency or importance since they are so variable depending upon the nature of the surgical interference required, the age of the patient, the time of year and other variables. Such a classification does, however, make it possible to see at a glance the wide variety of risks which may be encountered. In subsequent paragraphs I shall attempt to outline methods for combating at least some of them.

- 1 Risks due to anesthesia
- 2 Hemorrhage
- 3 Shock.
- 4 Postoperative pulmonary lesions
- 5 Phlebotrombosis and thrombophlebitis pulmonary infarct and fatal embolus.

- 6 Infection
  - (a) Extraneous infection of clean wounds
  - (b) Spread of pre-existing infection either into adjacent tissues or metastatic lesions
- 7 Imbalance of biochemical processes.
  - (a) Dehydration
  - (b) Electrolyte imbalance
  - (c) Hypoproteinemia
- 8 Fat embolism
- 9 Disturbances of sugar metabolism, in the diabetic and in the potential diabetic.
- 10 Risk in the presence of cardiovascular disease
- 11 Risk due to damaged kidney function
- 12 Catastrophes—accidental (operative) injuries to essential structures e.g., common duct ureter large arteries, essential nerves, et cetera

### ANESTHETIC RISKS

Whereas children and younger adults tolerate and are benefited by moderate doses of the barbiturates and of avertin as a preoperative procedure in order that, on the one hand, the patient's nervous system may be quieted and fear and apprehension may be allayed, and on the other, that induction of anesthesia may be rendered more smooth and less anesthetic required, such is not the case in older persons. For each five-year period after fifty years of age, the administration of barbiturates becomes, in our opinion, more and more hazardous. In the elderly and old we have come to the conclusion that their administration should generally be avoided, if at all possible, and if employed should be used in the smallest possible doses. As an alternative procedure we have become convinced that a combination of morphine and hyoscine (scopolamine) is both more satisfactory and associated with less risk.

Since July 1936 in our clinics at the Grace Dart Home Hospital and the Royal Edward Laurentian Hospital—both institutions for the care of the tuberculous—we have employed spinal anesthesia exclusively for the performance of first and second stages of thoracoplasty. For purposes of sedation we have used morphine and hyoscine in doses larger than have been in general use. Ninety minutes before operation the patient receives  $\frac{1}{4}$  grain of morphine and  $\frac{1}{100}$  grain of hyoscine subcutaneously. Twenty minutes before operation the condition of the patient is checked and if, as is usually the case, he is not sound asleep, the same dose is repeated.

Our experience with this method of sedation in many hundreds of cases, even in this type of light weight asthenic individual, has satisfied us that the method is more reliable and also that it is less dangerous than with other drugs.

With improvement in anesthetics, anesthesia has become more dangerous. This may appear to be a paradox but we believe it to be true.



As a corollary, a state of affairs has been brought about in consequence of which specialists in anesthesia have become more necessary and the length of the course of training required for such has been substantially increased. Any anesthetist who does not fully understand and appreciate the toxicity of the drugs which he employs must himself be considered a menace. The modern anesthetist deserves an important standing both in hospitals "set ups" and in the community. At McGill University these facts have been recognized by the establishment of a Department of Anesthesia, headed by a director of professional rank.

There is one type of operative risk which appears to be overlooked more frequently than others. I refer to asphyxia in the immediate post-operative period in consequence of obstruction of the airway by vomitus. Every year there occur in a few clinics on this continent deaths of persons, commonly children, who had been considered good risks and who were expected to recover perfect health, in consequence of emergency operations without adequate preoperative preparation.

It is of the utmost importance when it is deemed advisable to carry out emergency operative procedures, that is to say after but a short period of hospitalization, that the length of time which has elapsed since the last meal be determined. If there is any suspicion that the stomach may be full, in the first place the anesthetist must be warned that this is the case and, in the second place, if vomiting has not occurred during the induction period the patient must be carefully observed (not by a nurse or junior intern but by a responsible member of the anesthetic or surgical staff) until such time as the patient has returned to more or less complete consciousness. Such attendant should, moreover, be equipped with the necessary apparatus (mouth gag and suction appliance) so that the airway may be kept clear. Death as the result of this catastrophe occurs most usually during the period between completion of the operation and return of the patient to the ward. Needless to say it constitutes a tragedy which need not and should not occur.

#### HEMORRHAGE AND SHOCK

I believe that in most clinics operative shock has been recognized as being in fact the combination of several unfavorable influences. Chief of these unquestionably is blood loss, both that suffered during the actual operative procedure and that lost into the damaged tissues during the immediate post operative hours or days. Since copious hemorrhage is dramatic, its importance was recognized long before that which is designated by the experts as plasma loss. It is a matter of common knowledge that wounds that have been adequately drained pour out a variable amount of serous fluid, also that, unless more than usual care is exhibited in operative technique, the exudation of vascular

fluid about the operated site is evident. The gentleness with which the tissues are handled, the adequacy of hemostasis and the employment of a minimal amount of the least irritating materials for ligatures and sutures, all play their part in conserving fluid in the circulatory system.

During World War I, blood transfusion was in its infancy and very few wounded soldiers ever received the benefits of this procedure. Gradually between the two wars technical methods for blood transfusion were perfected and more especially the reasons for unfavorable or disastrous reactions were discovered and means employed for their elimination. This aspect of the subject is presented elsewhere in this volume.

### POSTOPERATIVE PNEUMONIA AND ATELECTASIS

Although the introduction of the sulfonamides and of penicillin has minimized the frequency of pneumonia during the immediate postoperative period and has to an even greater extent reduced the mortality rate from this complication, such lesions still occur and occasionally patients die from this cause. Atelectasis or massive collapse of one or more lobes not infrequently develops unless great care is exhibited to avoid its incidence. Both of these phenomena are especially prone to occur in operations upon the upper abdomen and in intrathoracic interference.

It is unnecessary to urge that the most certain way to prevent pneumonic consolidation is the postponement or cancellation of all elective operative procedures upon persons known to be suffering infectious processes in either the bronchial tree or in the upper respiratory passages. Furthermore, it would seem to be unwise to perform any operation which requires a general anesthetic during periods when epidemics of respiratory disease are prevalent.

Although it is difficult to establish proof that pulmonary lesions are less likely to complicate convalescence when spinal anesthesia rather than an inhalation method is employed, our own results in many hundreds of cases of pulmonary tuberculosis subjected to thoracoplasty with but few examples of spread of the disease, has convinced us that the method of anesthesia is of the greatest import.

This is not the proper place to attempt to discuss critically the various theories with regard to pulmonary atelectasis as a postoperative complication, although it would seem clear that in the majority of cases occlusion of one or more of the bronchi is responsible. Numerous experiments have proved that it is possible for material from the pharynx to slip down into the bronchial tree and also for exudates, mucus or blood to flow over from a diseased part of the lung and occlude the bronchus in another part.

Although the sudden occurrence of atelectasis during the course of operation is not common, it does occur frequently enough to emphasize the need for the anesthetist to be on the lookout for such an incident and, furthermore, it should be the duty of the anesthetist to be as sure as possible that all five lobes of the lungs are functioning before the patient leaves the operating room.

We have made it a practice for many years to employ spinal anesthesia for all of the more major operative procedures in the abdomen and for most of those on, and in the thorax. Most of these patients are hospitalized for a period of forty eight hours or longer prior to operation for various reasons. During this time an attempt is made to impress upon the individual to be operated upon the necessity for him to cough vigorously during the early postoperative period and if, as is not infrequently the case he does not know how to cough instruction is given to him. Following operation, then at intervals of about one hour, the patient is ordered to cough. Vigorous coughing in this fashion results in a two fold favorable result, namely that on the one hand, plugs of mucus or other material are likely to be dislodged and, on the other hand, the relative anoxia induced by coughing results in a more adequate inspiratory effort.

In patients operated upon under general anesthesia it is not of course possible to have them carry out instructions during the immediate postoperative period. In such cases the breathing of carbon dioxide 6 or 7 per cent results in both an increased respiratory effort and in the great majority of cases induces the cough reflex. If these simple procedures are not effective in inducing complete aeration of all lobes of the lung, bronchoscopic suction of the bronchial tree should be carried out without hesitation. If a bronchoscopist is not immediately available the passage of an intratracheal catheter through a direct vision laryngoscope such as is commonly carried out in the induction of anesthesia by the intratracheal method will usually suffice to clear at least the stem bronchi.

Since I have on several previous occasions<sup>2</sup> referred to the comparative absence of pulmonary complications following laparotomy if properly designed transverse incisions are employed, no further reference to this aspect of the subject will be made here.

#### PULMONARY EMBOLUS

Although venous thrombosis is considered in some detail elsewhere in this volume, the lesion is of such paramount importance as an operative risk that it seems reasonable to refer to the subject at this point.

Pulmonary embolus consequent upon phlebothrombosis or thrombophlebitis, is, in the opinion of many surgeons the most tragic incident which may occur to the individual who has been subjected to operation when as is so commonly the case the patient who has been

operated upon for a comparatively harmless condition suddenly dies on the seventh to twelfth postoperative day as the result of occlusion of the pulmonary artery. As a rule the tragedy occurs in a case which has hitherto appeared to run a benign postoperative course although it is usual on checking back on the record to discover that a low grade fever has continued from the time of operation.

Owing to the fact that the incidence of pulmonary infarct or fatal embolus is irregular in that it is more frequent in certain parts of the continent than in others, and that it is seasonal—insofar as our clinics in Montreal are concerned the majority of cases occur during February, March and April—and also since the number that occur in different years is so variable, it has not been easy to determine the factors which influence its development. It would seem clear, however, that stasis of blood in the veins of the lower extremity and a shortening of the prothrombin time are separately or jointly of paramount importance.

The majority of pulmonary emboli have their origin in the great veins draining the lower extremities and, as Homans has pointed out, it is probable that the posterior tibial is the usual point of origin.

Among the procedures which are believed to minimize the frequency of the disease are those which are calculated to increase the rate of flow through the veins of the lower extremity. For this purpose early exercise especially of the legs is recommended and would seem to be very important, it would seem, however, that if a technic be employed which makes it possible to permit the patient to get out of bed on an early postoperative day, the incidence of at least fatal embolus would be minimized.

In staged operations, particularly in the elderly, as for instance resections of large bowel or rectum in which preliminary colostomy has been deemed advisable, an effort should always be made to have the patient ambulant between stages. A notable exception in this regard is thoracoplasty for tuberculosis, fortunately pulmonary embolus in such cases is almost unheard of.

When the patient exhibits suspicion of thrombosis in the posterior tibial vein or other suggestion of phlebothrombosis, and also in cases in which for one reason or another activity in bed has been interfered with and prolongation of the bed period has been deemed advisable, we have made it a practice to estimate both the coagulation time and the prothrombin time. If either or both of these examinations suggest either a low normal or a below normal time, we have made it a practice to employ heparin and dicoumarin so as to force both of these records up.

During the last four years ligation of the common femoral or iliac veins has become generally employed in many clinics. Allen and his associates in Boston<sup>2</sup> and Bancroft in New York deserve the credit,

I believe, for the recognition of the fact that the procedure is well-nigh harmless and that extension upward into the iliac veins may be prevented by this simple maneuver. In the April 1945 number of this publication, Bancroft illustrates the value of the procedure.

#### WOUND INFECTION

Among the important risks of operation to which the patient is subjected, none is more distressing than that due to the entrance of bacteria with consequent infection of clean wounds and the spread of a preexisting infection either into adjacent tissues or as a metastatic lesion.

**Extraneous Infection of Clean Wounds**—Since the time of Lister the technic of surgical procedures has been gradually developed so that today the infection of clean wounds has been largely eliminated. There are, however, a sufficient number of cases of hernioplasty, ligation of the internal saphenous vein and other more or less simple operative procedures that are followed by wound infection. It is evident that space is not available in this short contribution to cover surgical technic in a general fashion, there are, however, certain features of operative procedure which are more commonly overlooked, I believe, than others. Chief among these is the importance of gentleness in handling the tissues, this includes the importance of sharp, preferably scalpel, dissection rather than blunt dissection in exposing the lesion.

Although it is not possible for the majority of surgeons to carry out difficult procedures without handling the tissues, we have made an attempt to impress upon our residents the importance of developing a mental attitude as the result of which they feel that only under exceptional circumstances should a sponge be touched with the fingers or a finger placed in the wound. Although the great majority of rubber gloves are safe in that no openings exist, there are, nevertheless, a small proportion of gloves which for one reason or another are porous.

As a result chiefly I believe of the numerous articles written upon the subject by Allen Whipple and his associates, notably Melenev, the importance of strangulation of the tissues with consequent likelihood of infection through the employment of heavy suture material has been generally recognized. A larger and larger number of surgeons throughout the continent have in consequence learned to use light-weight sutures. It is not, I believe, of the utmost importance whether chromic catgut, silk, cotton, nylon or steel be employed so long as the sutures used are fine. It is clear in this connection that if light-weight material be employed it is not possible to strangulate the tissues since the suture material itself will break. A further common mistake in connection with wound closure is that an unnecessary

large number of sutures are introduced, with an increased danger of interference with blood supply as a consequence

**Spread of Preexisting Infection**—This heading might well be made the subject of a complete thesis, it is, however, possible here to do little more than refer to the matter. Probably the most common example of the risk of spreading infection into adjacent tissues is in connection with disease of the appendix, either gangrenous appendicitis with infection by anaerobic micro organisms or appendicitis complicated by abscess due to pyogenic bacteria. The risk of infection in either of these cases is two-fold, namely soiling of the peritoneal cavity and, as a more likely though usually less serious risk, infection of the abdominal wall.

With reference to the former, namely soiling of the peritoneal cavity, this is most surely avoided by the employment of an adequate incision which allows the operative field to be clearly exposed so that the operative procedure may be carried out under clear vision and the small bowel protected by saline packs before the infected field is opened.

With regard to the prevention of infection of the abdominal wall, we have made it a practice for many years when opening the abdomen in cases in which infective material is thought to be present to cover the abdominal wall with an infinitely thin layer of bipp prior to opening the abdominal cavity. This technique has been described on more than one occasion<sup>3</sup> and will not be further indicated here.

Since the capacity of the tissues to overcome contamination is greatly interfered with by strangulation by sutures, these should be introduced loosely and in the smallest possible number. In the dangerously infected case we have made it a practice to introduce large gauze packs soaked in liquid paraffin and, to which either bipp or sulfathiazole emulsion (M.G.H. formula)<sup>4</sup> is added. By means of such large packs the necessity for any suturing of the abdominal wall other than two or three silkworm gut sutures through the skin to prevent extrusion of the packs is all that is required. In such cases, which are of course unusual, delayed primary or secondary suture is carried out at the end of four, six, eight or ten days.

#### IMBALANCE OF BIOCHEMICAL PROCESSES

The University of Pennsylvania group present in this volume the importance of dehydration, electrolyte imbalance and disturbance of protein metabolism as causes of increase in operative risk. It is not my purpose to attempt to add to their contribution in this regard but simply to urge the importance of adequate preoperative estimation of these essential factors in body physiology and the necessity, if serious or even fatal results are to be avoided, for correction, insofar as possible, of such abnormalities.

Improvement and simplification in methods for detection of imbalance or depletion in connection with these essential aspects of body function owe much to the stimulation of war effort and it is to be expected, I believe, that the tragic experiment which is now in process with thousands of starved prisoners from the German camps may add much to our knowledge regarding the clinical phenomena which accompany starvation and dehydration. Techniques of estimation and means of correction of such fundamentally disturbed body physiology should prove of inestimable value to surgery in the early future.

Before leaving this subject I should like to issue a warning with regard to the indiscriminate use of water and sodium chloride by parenteral routes in both preoperative and postoperative care. It would appear to be true that human beings withstand moderate dehydration and salt depletion better than an excess of either water or sodium chloride. Our young men—residents and interns—have become so accustomed to intravenous medications that a word of caution in this regard is often advisable.

#### FAT EMBOLI

Happily, the occurrence of massive fat emboli is comparatively unusual or rare, it must, however, be borne in mind as a possibility in cases of fracture of the long bones and in certain operations upon bones, particularly of the osteotomy type. The limitations of space in this contribution make it impossible to do more than refer to this extremely distressing and sometimes fatal type of risk. It must suffice to draw attention to the fact that fat emboli may be demonstrated in the lungs, kidney and brain of a large proportion of all patients who die as the result of trauma. Wangenstein and his group have recently noted the frequency with which the vessels in the gastric submucosa may be occluded in the same way.

The risk of serious or even fatal plugging of essential end arteries by fat globules constitutes but one added reason for the exercise of extreme gentleness in the handling at all times of victims of trauma especially if such be associated with fractures of the long bones. The possibility of such an early complication is, moreover, one reason for the avoidance of immediate closure (by suture) of compound fractures.

#### DIABETES

All surgeons are familiar with the fact that in the diabetic, surgical procedures are carried out with a very substantial increase in operative risk and with a very grave likelihood of wound infection if prior to operation expert control of the diabetic state has not been accomplished. The fact that operation as such, and more particularly if even minimal wound infection occur, may precipitate the diabetic state in persons whose sugar metabolism is close to the borderline is less gener-

ally appreciated by surgeons I have already expressed the opinion<sup>2</sup> that healing of both primarily infected and clean wounds may be expected to progress more quickly and more favorably if, during the postoperative period, insulin is administered up to safe limits of tolerance

The role of diabetes in increasing the risk of operation is of so great importance that it has been made the subject of a special memorandum from our clinic by Doctors McKim and Fowler Their contribution proves, I believe, that this risk is one the seriousness of which can be almost completely eliminated by expert oversight

#### CARDIOVASCULAR DISEASE DAMAGED KIDNEY FUNCTION

As indicated in the early part of this section, we have encountered in recent years a larger proportion of elderly persons in our surgical wards than ever before The importance of degenerative changes in blood vessels, heart and kidneys has consequently increased In a separate section Powell has discussed the subject of damaged kidney function particularly in vesicle neck obstruction, consequently this matter will not be referred to here

Cardiovascular disease as a cause of increased operative risk is well recognized, the subject, however, is too complicated for consideration at this time

#### CATASTROPHES AT OPERATION

This subject need only be mentioned since it has been the experience of nearly all surgeons of any considerable experience to meet with such distressing situations In the training of our young men every opportunity should be taken advantage of to demonstrate the ease with which a portion of the common duct may be removed along with the cystic, if extreme care is not exhibited to identify all structures positively before the application of clamps Similarly, the risk of damage to the left ureter and even of the urethra in resection of the rectum, and of large vessels and important nerves in various properly established operative procedures in different parts of the body, should be appreciated by all surgeons, young and old, who accept the responsibility of exposing their patients to the risks of operation The training of our residents should include instruction in the proper procedures required to minimize the seriousness of such catastrophes

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## SURGERY AND DIABETES MELLITUS

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AND

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A PATIENT who has diabetes mellitus may, at times, be exposed to the added hazard of surgical procedures. If the diabetes is under satisfactory control and carefully supervised, the surgeon may and has a right to feel that the surgical risk will be identical with that of a patient who has no diabetes. This, however, is accomplished only by close cooperation between the surgeon, the physician and the laboratory. The essential requisites are (1) a proper physical examination and evaluation of the risk in general, (2) adequate control of the diabetes before operation, and (3) careful supervision of the patient after operation.

The physical condition of the patient must be taken into consideration. If the individual shows the degenerative changes associated with his diabetes these must be included in determining the operative procedure and evaluating the risk. Obviously, a diabetic with premature arteriosclerosis is a very different problem from an individual the same age who has no evidence of cardiovascular disease. It is not so much the age, but rather the actual physical condition of the patient and the degree of control of the diabetes, that must be evaluated. When these are taken into consideration the diabetes, per se should not increase the mortality rate, influence the surgical procedure or lengthen the time of healing of the wound.

The problem of operations on diabetics should be considered under two headings: (1) operations that are elective and in which the time of operation can be dictated by the control of the diabetes, (2) Emergency operations.

### ELECTIVE OPERATIONS

In this group the diabetes should be satisfactorily stabilized prior to operation. The urine should be free of sugar and acetone bodies.

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and the blood sugar should be normal. In many cases this optimal state may be difficult to bring about. Certain clinics permit a slight degree of hyperglycemia in the fasting state in elderly diabetics. Others feel that a small amount of sugar excreted postprandially is permissible. In our experience the chief considerations are (1) that the patient should receive an adequate diet, especially in regard to the caloric and protein intake and (2) should be utilizing that diet. If the patient is utilizing the administered carbohydrate and is in nitrogen equilibrium, there is little fear of acidosis during or shortly after the operation or during the period of wound healing.

In this clinic the diet of choice is our *high carbohydrate, low calorie, adequate protein diet*. Its advantages in surgery are as follows: (1) It tends towards glycogen storage. (2) Due to the extremely low  $\frac{FA}{G}$  ratio, the tendency towards ketosis is lessened. (3) The patient is able to take the diet at an earlier date after the operation. (4) It does not tend towards gastrointestinal upsets. (5) It is simple to prepare. (6) It tends toward nitrogen equilibrium more than diets lower in carbohydrate and higher in fat. (7) It does not require preoperative administration of carbohydrates or glucose intravenously.

**Insulin Dosages in the Surgical Patient**—Infection and absorption from traumatized areas, at times, cause marked loss of carbohydrate tolerance, and the degree of such disturbance bears no relationship to the extent of the infection or degree of the trauma. The extraction of a tooth may cause as much disturbance as a compound fracture of the femur, a small boil may cause as much loss of carbohydrate tolerance as a carbuncle. The important fact to bear in mind is that in either instance there may be a marked loss of effect, both from endogenous and injected insulin. Thus, under such conditions, insulin dosages must be increased, both in amount per injection and the number of injections. There is no rule by which one can estimate the dosage in all cases. *The patient should have as much insulin as is required, at the time it is required, regardless of the number of injections and the time of day or night.* The following is our routine procedure:

1 Crystalline insulin is preferred to protamine zinc insulin because it permits more rapid adjustment of the carbohydrate metabolism.

2 The insulin is given at frequent intervals, as a rule, every eight hours, that is at 8 A.M., 4 P.M., and at midnight. If control is not adequate in dosages up to 20, 20, 20 every eight hours, then the injections are changed to every six hours, that is at 8 A.M., 2 P.M., 8 P.M. and 2 A.M. It may be necessary to increase the injections to every four hours or every two hours or still more often.

3 Adjustment of the insulin dosage can be readily made in patients who have a normal renal threshold for glucose by collecting the urine at intervals throughout the day. It is our practice to collect as follows:

8 A.M.	to 12 noon
12 noon	to 5 P.M.
5 P.M.	to 10 P.M.
10 P.M.	to 7 A.M.
7 A.M.	to 8 A.M.

Each specimen is examined for sugar and the insulin dosage is adjusted according to the time of occurrence of the glycosuria. With this information, repeated estimations of the blood sugar are not necessary.

**Procedure on Day of Operation in Elective Cases**—A blood sugar reading is obtained in the fasting state. The usual dose of insulin is administered. Blood is then obtained one hour after operation and, if necessary, adjustment of the insulin dosage is made. If the surgeon decides that intravenous glucose therapy is necessary, a small amount of crystalline insulin is added to the solution—usually 10 units of crystalline insulin to 1 liter of 5 per cent glucose in physiological saline or 5 per cent glucose in distilled water. In patients receiving protamine zinc insulin and who have received their usual morning dose, no added insulin is necessary, provided the glucose is administered slowly. The day after operation a specimen of blood is obtained in the fasting state and further adjustments are made in accord with the findings.

The above method has been in use in this hospital since insulin has been available. It has therefore stood the test of time. It commends itself because of the simplicity of management. In our opinion complicated preoperative and postoperative routines are unnecessary.

#### EMERGENCY OPERATIONS

The problem in emergency cases is vastly different, especially if the diabetes is not under satisfactory control at the time. In such cases our routine is to estimate the level of the blood sugar and the degree of acidosis and, depending upon the severity of the diabetes and the degree of its control, insulin is given either intravenously or subcutaneously or by both routes. The blood sugar is then determined at hourly intervals and if the blood sugar is falling, that is, sugar is being oxidized or stored, the operation is performed.

In the preparation of a patient for operation it is, of course, also essential to restore the electrolyte and fluid balance if these are disturbed. This is accomplished by intravenous saline. Glucose and insulin may be included at the same time if necessary.

A note here should be made of two conditions, namely, (1) surgery of the lower extremities and (2) the differential diagnosis of abdominal pain.

#### SURGERY OF THE LOWER EXTREMITIES

The diabetic in many cases, especially those of long duration which have been under poor control, may develop a sensory neuritis and in

addition may have premature arteriosclerosis. In the presence of these complications there is an added risk to surgical procedures involving the extremities. Here again the important fact in evaluating the risk is the physical examination. If the patient has a sensory neuritis, he is more apt to injure the limb without experiencing pain. He may allow pressure necrosis to occur largely for the same reason. There is a decrease in the appreciation of changes in temperature and the part may be burned without the patient experiencing any sensation of heat. With the loss of this protective mechanism there is often another associated factor and that is the diminished circulation. In such cases it is impossible to increase appreciably the circulation to a given area and as a result there is loss of the mechanism to remove heat from an area subjected to too high a temperature or to supply an increased amount of blood to tissues with an elevated metabolism.

If as the result of an infection or an inflammation, there is an increase in the tension in the tissues, this will rapidly reduce the circulation, ischemia may result and rapidly lead to gangrene. Here again if there is careful supervision of the patient, much can be done to prevent a minimal lesion from increasing to such an extent that a major surgical procedure would be imperative.

At times it is difficult to assess the risk involved. The use of arteriograms, x ray of vessels for calcification, oscillometric determinations, skin temperatures and so forth are perhaps of some interest, but are not necessary. The important factor is the temperature of the limbs. Examination should be made with the patient in the recumbent position with the legs exposed at room temperature for twenty minutes prior to examination. Careful comparison should then be made of the temperature of one leg as compared to the other and with temperature changes in each part of the limbs. If the foot is warm there are no restrictions to the surgical procedure, but if the limb is cold then even minor operations will not be successful and will lead to gangrene. When this occurs, amputation is indicated at a site where adequate circulation exists.

In the treatment of a lesion involving the lower extremity the problem is not whether the patient is or is not a diabetic or if he is one, how long he has had the disease or what his age is. The important factor is the circulation of the extremity. *If the circulation is impaired* then every effort must be made to allow the deficient blood supply to operate at its maximum. The following should be observed:

- 1 The limb should not be elevated.
- 2 Alcohol dressings or antiseptic solution containing a protein precipitant should not be used.
- 3 Heat or hot dressings should not be applied.
- 4 Dependent drainage should be established if possible, or "curtain drainage" by the use of dressings soaked in mineral oil.

- 5 If there is obvious tension in the tissues, due to inflammation, this must be relieved immediately
- 6 The limb should be exposed at room temperature
- 7 If there is evidence of a spreading lymphangitis, the use of "evaporating lead lotion" is recommended
- 8 The use of sulfonamides or penicillin is not contraindicated

#### THE DIFFERENTIAL DIAGNOSIS OF ABDOMINAL PAIN

The differential diagnosis between an uncomplicated diabetic in acidosis who is vomiting and has abdominal pain and one with the same symptoms and an acute abdominal lesion presents a special problem. The picture is further complicated by the fact that in both conditions the leukocyte count may be elevated. There are no hard and fast rules to establish the diagnosis. If after careful consideration there is any doubt of the diagnosis then the patient should be subjected to the risk of operation. The following points should be considered:

- 1 In diabetic acidosis the patient usually has been vomiting sometime before the occurrence of the abdominal pain. When the patient has been given adequate treatment for the acidosis and has received from 1 to 3 liters of physiological saline, the pain often subsides.
- 2 In acute intra abdominal lesions the patient usually complains of pain and then starts to vomit. At times, both pain and vomiting occur almost simultaneously and in such cases one must rely on other factors in establishing a diagnosis.
- 3 The white blood count may be elevated in both conditions and should not be used in a differential diagnosis.
- 4 In diabetic acidosis the patient does not complain of pain or tenderness on rectal examination.
- 5 If in spite of the above observations, the diagnosis is still in doubt, the patient should be subjected to operation as soon as he can be properly prepared, as outlined previously.

#### RISK INVOLVED IN USE OF ANESTHETICS

*Local Anesthesia*—The injection of local anesthetics is associated with a certain degree of trauma and increases the tension in the tissues. The latter especially may interfere with the circulation. The use of such anesthesia is definitely contraindicated in operative procedures involving the extremities. The use of an ethyl chloride spray is also contraindicated because the resulting freezing of the tissues may lead to a gangrenous condition.

*Intravenous Anesthesia*—This type of anesthesia should be restricted to diabetics who are free of any evidence of acidosis. In an emergency operation, on a patient who has an acidosis with an associated disturbance in respiration, intravenous anesthesia is contraindicated due to the effect of the anesthetic on the respiratory center.

*Spinal, Caudal and Paravertebral Block Types of Anesthesia*—These do not present any especial hazards in the diabetic.

*Inhalation Anesthesia*—Possibly the anesthetic which causes the least disturbance is cyclopropane. This has the advantage of a rapid recovery rather than a prolonged period of unconsciousness following the cessation of administration. This factor is of importance in severe diabetics especially if an emergency operation has to be performed while the patient is suffering from an acidosis. If the patient is adequately prepared for operation and the diabetic condition is under satisfactory control, then the choice of anesthesia can be left entirely to the anesthetist. The use of nitrous oxide, if properly administered, is preferable to the use of ether anesthesia. Chloroform should not be used.

*Refrigeration Anesthesia*—This type of anesthesia is of value in a limited number of cases in which other types of anesthesia would increase the operative risk. The literature on the subject is extensive. It is our impression that, from the standpoint of anesthesia alone, most patients can be given a spinal or cyclopropane anesthetic without materially increasing the risk.

#### SUMMARY

There are three main factors in the consideration of the risk involved in surgical procedures on a patient with diabetes mellitus. From the standpoint of the surgeon the important fact is the physical condition of the patient and not the details of his diabetic condition.

From the standpoint of the physician the important fact is the adequate control of the diabetes. If this is satisfactory the diabetes per se, should not influence the surgical procedure.

In respect to the laboratory, the importance of its function lies in its capacity to supply quickly, and at all times the chemical analyses necessary to enable the physician to control the diabetes, which will enable the surgeon to proceed according to the recognized technique employed in the treatment of patients who are not suffering from diabetes mellitus.

A great deal has been written outlining complicated procedures in preoperative and postoperative management of patients with diabetes mellitus. These do not lower the operative mortality. They are unnecessary and only serve to complicate a simple problem. If there is satisfactory cooperation between the surgeon, physician and the laboratory, the preinsulin concept of the risk involved in operations on diabetics will pass into its rightful place in history. There is no reason for and no excuse for an increased operative mortality in diabetics.

## IMPAIRED RENAL FUNCTION IN VESICAL NECK OBSTRUCTION

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DURING thirty-five years with the Urological Department of the Montreal General Hospital, it has been my good fortune to observe the miraculous strides in Urology, especially in the diagnosis and management of vesical neck obstruction. This period, nevertheless, has had its moments of chagrin, alternating pessimism and optimism, optimism due to the realization of the vast strides accomplished, pessimism because of the "laissez-faire" attitude of the public and many of the medical profession, an attitude so obstructive to early diagnosis and treatment.

One might expect the annual examination afforded to policyholders by the majority of insurance companies to have provided an early diagnosis of vesical neck obstruction in many instances. The facilities offered to the public by free clinics might have materially reduced the number of cases progressing to a dangerous stage. Why the average office examination is carried to its apparent conclusion without any attempt to check the condition of the rectum is beyond my ken. Not only is an early adenomatous lesion missed, but early carcinoma of the prostate, so notoriously symptomless, progresses beyond a radical petineal section. Early carcinoma of the rectum develops into an inoperable infiltrating obstruction until a colostomy can give but temporary relief.

### CAUSES OF VESICAL NECK OBSTRUCTION

The lesions of childhood, including the congenital valve of the prostatic urethra stricture, and the more rare hypertrophy of the colliculus, are the first to be considered. These lesions are frequently associated with incontinence and enuresis. Persistence of symptoms, for the alleviation of which all palliative measures have failed, calls for a careful urologic study. Simply to recall the inevitable complications of hydroureter and hydronephrosis with their tragic result of renal failure would emphasize the urgency of such a study.

Sarcoma of the prostate, which one might call a clinical oddity, is seen chiefly in infancy and old age. In our records of over thirty-five years, two infants and one man of 75 years have had a positive diagnosis from biopsy.

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Marked cystocele, prolapse, or both, in the female patient most certainly should be included among the causes of bladder neck obstruction. It is surprising, however, how seldom we find renal function impaired in these cases. It is astounding how many of these women can go on with much residual urine and yet show no signs of infection, stone, hydroureter or hydronephrosis. Seldom do we find lowered renal function.

Attention is naturally concentrated largely on adenoma, carcinoma, fibrotic prostatitis with contraction of the vesical neck, and hypertrophy of the median bar associated with the subvesical glands so ably described by Albarren. The occasional retention caused by the hypertrophy of the interureteric ridge, often referred to as the muscle of Bell, should not go unmentioned. Strictures of the prostatic urethra, the result of trauma, so frequently associated with fractures of the pelvic girdle, form another group which calls for all the ingenuity of the attending surgeon.

All of these clinical entities if allowed to go untreated will lead eventually to renal dysfunction.

#### DIAGNOSIS

Perhaps an almost universal opinion among the laity, that nocturnal frequency after the fifth decade is to be expected, is largely responsible for the delay in diagnosing impaired renal function. The public must be divorced from this fatalistic idea that nocturnal frequency is a result of old age.

Disregarding the early symptoms, there is a gradual back pressure exerted upon the kidneys subjecting them to inevitable damage, so often complicated by hydroureters and hydronephrosis and even ureteral reflex. The final stage of pyonephrosis and uremia becomes inevitable if relief is not sought.

Usually the first consultation with a urologist is preceded by one or more attacks of retention, often pyuria. Relief is sought because of loss of sleep, frequently severe hemorrhoids and an upset gastrointestinal tract.

The insidious onset of carcinoma usually finds the patient entering into an obstructive stage with definite x-ray findings of metastases. Unquestionably these cases could be recognized were *rectal examination* made a fetish and perineal biopsies done in all doubtful cases. The rectal examination as mentioned is frequently avoided, but its importance cannot be overemphasized. Because the public is particularly interested in hypertension a blood pressure reading is always made, but the rectum often remains, both to the patient and his examining physician, in a state of complete oblivion. No digital examina-

tion should be completed without the precaution of posturing the patient in the knee-chest position—right, left and lateral. Thus added detail may well result in the detection of an early carcinoma of the rectum, many of which are missed in the ordinary knee-chest position.

The first responsibility of the examiner after a careful physical examination, when his attention is attracted to the genitourinary system, is a careful *percussion and palpation of the suprapubic area*. It is amazing how many distended bladders are overlooked because of the statement, 'I pass my urine easily but very often and in small quantities.'

Blood pressure is most important. Both hypertension and hypotension may affect renal function, the former from circulatory disturbances due to sclerosis, the latter by slowing up renal circulation and inhibiting the normal selective excretion and secretion.

Cardiovascular disease, with or without decompensation, adds to the gravity of the situation. An *electrocardiogram* should be taken routinely.

The actual obstruction of the bladder neck may go on for a long time without signs of renal dysfunction, but this will eventually catch up on the individual and lead to many pathological changes locally and generally. Its prevention is our most frequent problem and raises the urgent question of drainage. Where prostatectomy is indicated, and the patient is in good condition, drainage can be omitted and immediate operation carried out. This does not apply to acute retention where immediate relief from retention is demanded.

If a soft catheter is tried unsuccessfully, often a prostatic curved mandrin inserted in the catheter will be successful. The sudden emptying of an overdistended bladder is regarded as a dangerous procedure by many, but is considered harmless by others. I firmly believe that many cases are seriously compromised and that "recoil" can be of very serious consequence. Decompression is a precaution well merited when dealing with a class of patients who have passed frequently into the sixth or seventh, even eighth decade. Their metabolism is waning, their reserve is lowered, and their myocardiums are more or less weakened.

In younger normal individuals kidney reserve may well be estimated at about 70 to 80 per cent—what a change ripened age has caused! Under normal conditions these men will carry on with apparent good health, but put a little extra strain on the cardiovascular system and renal mechanism, and recall what often happens. It should not be a surprise that fatalities occur, but it is a surprise that the patients can be subjected to operative procedures and come through with unusually few complications.

It causes no renal impairment. While it does not give the relaxation of spinal anesthesia, it is probably the most widely used. Careful insulation of all operating room equipment will avoid the dangers attending its highly inflammatory properties. Pentothal is a safe intravenous medium. It is pleasant to the patient and effective in its action. By the drip method a prolonged sleep with good relaxation can be maintained.

While open suprapubic cystotomy is looked upon as a simple operation, a review of the literature and our own records reveals a mortality of about one third that resulting from total prostatectomy.

In this article I do not intend to enter into the controversy concerning the relative merits of the different methods of prostatectomy. Undoubtedly many operations are best done by perineum. The early carcinoma leaves no argument. The transurethral approach is admittedly the method in all cases of advanced carcinoma. The median bar, bladder neck obstruction, contraction from fibrotic prostatitis and small adenomatous growths are undoubtedly satisfactorily cured by transurethral resection. In the case of large adenomas, unless the risk is too great, many prefer a two-stage operation by the suprapubic route. Unquestionably many aged patients with poor function can be relieved by transurethral resection when any other method would be fatal.

The controversy between adherents of the one stage open operation, one stage blind enucleation, and the two stage operation still remains an open argument. A report from the actuarial departments of two large insurance companies shows more rejections due to pyuria following transurethral resections than following other types of operations.

The method of approach which the operator feels will in his hands afford the best chance for a successful termination is the method indicated. To be dogmatic and assert there is only one method is wrong. All have their merits. Unquestionably many transurethral resections are done by urologists because the patient demands that method. Moreover, the operation is used frequently in a young group of patients who have very little obstruction.

#### POSTOPERATIVE COMPLICATIONS

Following the removal of the prostate many complications arise with damaging results to the kidneys. *Shock*, with its natural sequence of lowered blood pressure, results in a temporary inhibition of urinary output. In the absence of hemorrhage, blood plasma and 5 per cent glucose in saline is indicated as well as cardiac and respiratory stimulants. Coramine and caffeine are both valuable.

*Hemorrhage* is perhaps the most frequent cause of alarm. During its acute period every organ suffers and prompt measures are demanded.

Fresh citrated blood is given immediately and steps are taken to control the bleeding, such as the proper insertion of a hemostatic bag or pack. Where hemorrhagic tendencies have been controlled as far as possible by either calcium or vitamin K with bile salts preoperatively, bleeding should not occur, but unfortunately it not infrequently is seen. The tightening of the bag following the introduction of more fluid will usually give the desired result. Absorbent gauze soaked in thrombin, yet in the experimental stage, may prove a boon. Fibrin foam has proved to be a valuable hemostatic medium and has been used to a moderate degree with splendid results. Our experience is limited to two cases, each a one-stage prostatectomy, and in each case a complete arrest of bleeding was brought about.

The late hemorrhage, which occurs days after operation, is dangerous, often because of its concealment. Presuming there has been no blood dyscrasia, late hemorrhage should not occur but the fact remains that it does in a disconcerting number of cases. The removal of the clot, a pack or reinsertion of the bag, permits no delay but the results are satisfactory. Blood transfusion must be promptly given. There seems to be a tendency toward incontinence thereafter, perhaps explainable by the reinsertion of the bag and stretching of the sphincter.

The grouping of all blood is important, with particular reference to the *Rh* factor. Before this rather disconcerting difference in bloods was recognized we had some few deaths unexplained by blood groupings, all the patients showed anuria and the kidneys at autopsy showed acute congestion with plugging of the tubules. The finding of an Rh-negative is particularly dangerous to the recipient who has had a previous transfusion of Rh-positive blood, or to the Rh-positive patient who may have had an Rh negative transfusion.

The use of bed rest during convalescence is passing through a transitional change. Prolonged inaction has been overdone, but I feel the pendulum has swung through an overardent arc. While resting in bed the patient should be encouraged to exercise his legs and his nurse should have strict instructions to change his posture frequently. Each of us can recall a number of patients who developed *renal calculi* from the stagnant kidney as a result of prolonged inaction in the dorsal decubitus position.

*Thrombophlebitis* is a serious complication and, I think, can be largely circumvented by these precautions. Every attempt should be made to get patients who have undergone operation out of bed at the earliest and safest moment. An excellent routine of measuring the calf muscles daily may give a premonitory sign of beginning thrombophlebitis before pain, soreness or apparent edema has set in. The ligation of the offending vein and the removal of the clot where possible will save and has saved many lives. These remarks seem far re-

moved from lowered renal function but they all have a very direct heating

*Infection of the bladder following any chosen procedure is frequent.* Most of the infections subside with the establishment of a normal functioning bladder, but some will progress to a pyelonephritis. The early establishment of a drip method of irrigation and the employment of a meticulous technic to prevent infections getting in through the drainage apparatus are usually successful. Sulfonamide therapy is most important and of the various drugs sulfadiazine is safest and seems to affect a larger group of organisms than the others. Beware of the sulfa allergic patient, tubular block does occur. Fortunately, premonitory signs frequently tell us of the approaching danger. Pain across the renal area and blood in the urine will warn us to stop the drug and alkalinize the patient.

*Ileus*, fortunately uncommon, is an alarming complication and its onset has a dire effect on urinary output. The prompt use of a Levine tube is of inestimable value. Many drugs are recommended but it is difficult to evaluate their efficiency. Pituitrin and prostigmine are the most commonly used. Hypertonic salt solutions intravenously, dextrose and water, glucose and saline, all may be given a trial. Frequent enemas, particularly milk and molasses, must be tried. Colostomy may have to be resorted to in extreme cases which show no improvement with more palliative measures.

#### SUMMARY

The most frequent cause of renal inefficiency is failure of complete bladder drainage. The whole question of such drainage is a live one and a great deal of thought should be given to the pros and largely the cons of indwelling drainage.

Bladder neck obstruction associated with cardiovascular disease is almost always accompanied by renal dysfunction and forms a group upon which much of our concern should be concentrated. The age of the average patient, accompanied by a general lowered metabolism and often a mental deterioration creates anxious moments in surgery of the bladder neck. Yet such surgery has its compensations. With all the pitfalls the results generally are excellent. No group of patients are more grateful. The surprising fact remains that we have lowered the mortality and achieved results of which we did not dream some years ago.

The explanation definitely rests with the better methods of diagnosis, the meticulous attention to every detail of renal function and bladder drainage, the realization that prolonged drainage will in most patients who are obviously poor surgical risks, change an almost certain fatality into a grateful, live and happily functioning individual.

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## COMPLICATIONS OF BLOOD TRANSFUSION

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Whole blood transfusion is being employed on an ever increasing scale. When there is great blood loss, the use of large quantities of whole blood is to be encouraged. The great majority of badly injured and desperately sick patients require, or are greatly benefited by, transfusion. This is particularly true prior to and during operation. When any therapeutic procedure becomes widely used, there is a tendency to employ it without sufficient consideration being given to the possible associated dangers. The purpose of this communication is to discuss the complications of whole blood transfusion and to point out methods of safeguarding the desired increase in whole blood therapy.

The complications of whole blood transfusion may be outlined as follows:

### I. Immediate untoward reactions

#### A. Hemolytic

1. Intravascular hemolysis of incompatible donor cells
  - a. Intergroup (ABO)
  - b. Intragroup (Rh)
2. Intravascular hemolysis of recipient's cells
3. Intravascular hemolysis of compatible donor cells
4. Transfusion of hemolyzed blood

#### B. Pyrogenic

#### C. Allergic

#### D. Circulatory overload

#### E. Embolic

### II. Transmission of disease

#### A. Infectious hepatitis

#### B. Malaria

#### C. Syphilis

#### D. Other diseases

Of all the complications listed above, the hemolytic reaction resulting from transfusion of incompatible cells is the most important because it often results in a fatality. The pyrogenic reaction is next in

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importance because of its frequent occurrence. It is very rarely fatal of itself but may be dangerous when the patient is in very poor condition.

## 1. IMMEDIATE UNTOWARD REACTIONS

### HEMOLYTIC REACTIONS

1. *Intravascular Hemolysis of Incompatible Donor Cells (Intergroup Reactions).*—This type of reaction occurs when the cells of the donor are incompatible with the plasma of the recipient. Thus A, B or AB blood given to an O patient, B or AB blood given to an A patient, and A or AB blood given to a B patient will result in a hemolytic reaction.

For discussion, it is best to divide the manifestations of hemolytic reactions into two stages: (1) the immediate hemolytic crisis; (2) the subsequent renal complications.

1. *The Hemolytic Crisis.*—The clinical manifestations vary greatly from one patient to another, possibly depending upon the antibody titer of the recipient's plasma. At times, a patient may receive 500 cc. of definitely incompatible blood and display no symptoms at all. In other instances, 20 to 50 cc. may produce a most severe reaction.

The reaction most commonly begins after 100 to 200 cc. of blood have been administered. The patient usually suffers a severe chill, pain in the lower back, substernal oppression, and perhaps nausea, vomiting and involuntary micturition and defecation. There may be spontaneous bleeding from needle-puncture wounds or other exposed capillaries. It is said that the blood pressure rises initially. Subsequently, the patient may go into a state of shock associated with a very low blood pressure and a fast, weak pulse. At this point, it may be necessary to institute treatment for the shock. Plasma or compatible whole blood transfusions are recommended. After the chill, the temperature may rise to 105°.

The initial reaction is rarely immediately fatal. Most commonly, the patient recovers from the chill, etc., and appears completely well in a few hours. The first urine passed after the reaction is dark brownish-red in color, shows a positive test for protein, contains a few red cells and a fair number of pigmented casts. The benzidine test is positive.

2. *The Renal Complications.*—Following recovery from the initial reaction, the patient may (a) show no further signs or symptoms other than a transient bilirubinemia; (b) show transient oliguria with nitrogen retention and then go on to excrete large quantities of urine and recover; (c) show persistent oliguria with increasing nitrogen retention and death in uremia; or (d) show oliguria leading to complete anuria or show complete anuria from the start. In cases of complete anuria the patient almost always dies in uremia but a few produce a



diuresis and recover. Rarely even the patient who shows a marked diuresis continues to retain nitrogen and die.

Death from renal failure usually occurs in from four to ten days. If the patient has received less than 250 cc of incompatible blood the chance for recovery is usually good. If he has received 500 cc or more, the prognosis is generally poor.

**PATHOLOGY**—The most characteristic postmortem findings in the patient who has died as a result of the transfusion of incompatible blood are seen in the kidneys. These are larger than normal and a bit more firm. The cut surface bulges a bit from the capsule and is generally pale. The cortex is markedly thickened and pale. The microscopic picture is characterized by almost normal glomeruli, distended proximal convoluted tubules and acellular casts in the collecting tubules which stain pink with the ordinary hematoxylin-eosin methods. The epithelium of the convoluted tubules may show evidence of regeneration, presumably following cellular damage. There may be round cell infiltration around extruded hyaline casts or blood vessels in some areas. The collecting tubules contain pigmented casts and may show necrosis of the tubular epithelium adjacent to the casts.

The pathological picture in the kidneys cannot be considered pathognomonic for a transfusion of incompatible blood. An indistinguishable picture may be caused by sulfonamides, shock, crush and probably by some other conditions or combination of conditions. It is well to mention at this point that an appreciable number of battle casualties admitted to field and evacuation hospitals have developed oliguria leading to uremia and death. At autopsy, the kidney lesions may not always be differentiated from those resulting from incompatible blood transfusion. The etiology in most cases is not clearly understood. This syndrome must be borne in mind since it has caused considerable confusion in the past.

**TREATMENT**—The treatment of hemolytic transfusion reactions is very unsatisfactory. The immediate reaction is rarely fatal. All transfusions must, of course, be stopped at the first sign of any adverse reaction. Ordinarily, the patient will recover from the chill and fever without treatment. Occasionally, the reaction may be of such severity that the patient appears to be in a severe state of shock, and plasma transfusion may be indicated.

The mechanism of renal failure is so poorly understood that treatment is almost entirely empirical. A multitude of plans for treatment have been described. These include alkalinization,<sup>1, 2, 3</sup> decapsulation of the kidney,<sup>4</sup> splanchnic block,<sup>5</sup> blood and plasma transfusion and the administration of such diuretics as sodium sulfate.<sup>6</sup> None of these plans have been successful in a significant number of cases.

Alkalinization of the patient to a point where all urine passed is alkaline has been the most widely publicized treatment. The theory has

been that hematurin is more apt to precipitate in the kidney tubules if the urine is acid<sup>7 8</sup> The argument for alkalization loses much weight when it is pointed out that in all probability the renal damage will have occurred by the time alkalization can be effected It is obviously impractical, and even dangerous, to routinely administer alkali to all patients prior to transfusion The argument loses further weight when it is pointed out that cases have been observed in which hemolytic reactions have led to fatal uremia even though the patient's urine was alkaline throughout the entire episode Some investigators<sup>9</sup> have reported that the kidney will clear hemoglobin better if the urine is acid

In the present state of ignorance it is not possible to recommend any specific therapy When alkalization is attempted, care must be taken to avoid alkalosis Sodium bicarbonate, by mouth, is seldom satisfactory since it is usually poorly tolerated If intravenous alkali is to be used, one sixth molar sodium lactate, in units of 1000 cc, is the agent of choice Less satisfactory are sodium citrate or sodium bicarbonate in 4 per cent solutions They may be used in quantities up to 350 cc and are best given in divided doses A sterile solution of sodium bicarbonate is difficult to prepare without formation of the excessively alkaline sodium carbonate, unless sterilization is accomplished by filtration

In the treatment of patients who show oliguria or anuria, greatest stress must be placed upon proper regulation of fluid and salt balance The oliguric patients very often show an increased plasma volume even on a moderately restricted fluid intake If fluids and salt are administered in excessive quantities they will not infrequently develop fatal pulmonary edema This must be borne in mind in the care of all patients suspected of having kidney damage

It is difficult to state how much fluid should be administered Each patient will present an individual problem Therapy must be guided by impressions gained from the general condition of the patient and determinations of the plasma carbon dioxide combining power, blood urea nitrogen and chlorides Ordinarily, one liter of an 0.85 per cent solution of sodium chloride and an additional liter of 5 per cent dextrose in distilled water will be sufficient parenterally If the patient is taking fluids freely by mouth the quantity by vein may be reduced or even eliminated

**PREVENTION OF INCOMPATIBLE BLOOD TRANSFUSION REACTIONS**—In the absence of satisfactory treatment, too much stress cannot be placed upon prevention of hemolytic reactions resulting from the transfusion of incompatible cells The methods of prevention consist in meticulous attention to the technics of blood grouping and cross matching The possibility of Rh immunization must be considered at all times If the supply of blood donors more than doubles the need it is advised to

use group O blood for all recipients with certain precautions to be discussed below

The most common *errors in blood grouping* are

(1) *Incorrectly labeling the specimen tubes* Obviously, the most careful tests are invalid if the specimen tubes are incorrectly labeled

(2) *Use of weak serum* If the liquid anti A and anti B serums are far outdated or if the vials of dried serum have been broken so that the powder has been exposed to moist air, their potency will have decreased Powdered serum that has been redissolved deteriorates in a few days particularly if it has been allowed to stand at room temperature, or if it has become contaminated

(3) *Use of contaminated serum* Contamination may result in false negative reactions resulting from decrease in antibody content It may also result in false positives as the result of production of nonspecific agglutinins by certain bacteria

(4) *Use of inadequate quantities of the serum* This error is most common when small portions of the dried powder are added directly to cell suspensions

(5) *Use of too light cell suspension* The clumps may be so small as to be overlooked A 2 per cent suspension, in terms of cell sediment, is most satisfactory It may be approximated by adding one full drop of blood to one cubic centimeter of saline

(6) *Use of too heavy cell suspensions* A heavy cell suspension may cause false negative readings by absorbing the agglutinin without gross clumpings It may also cause false positive readings if rouleaux formation is present and interpreted as agglutination The same errors may be made if the mixture is allowed to dry In warm, dry weather slides must be covered in a moist container to prevent evaporation

(7) *Reading the results too soon* Cells belonging to groups A<sub>o</sub> and A<sub>2</sub>B are weakly agglutinable Even with potent grouping serum there may not be visible clumping in less than thirty minutes when the test is performed on slides All slide tests should be allowed to stand for thirty minutes before making a final negative reading

(8) *Relying upon macroscopic examinations* All negative tests should be checked microscopically

(9) *Use of old cell suspension* Old cell suspensions are often contaminated Contamination may result in the production of nonspecific agglutination and thus cause false positive readings If the cell suspensions are sterile, they will react properly, although old cells tend to produce slower forming and smaller clumps

The most common *errors in the crossmatching test* include most of those found in blood grouping, plus the following

(1) *Failure to recognize hemolysis* When incompatible cells and serum (or plasma) are mixed, the result may be agglutination and/or hemolysis A fair number of fresh serums contain sufficient hemolysin

and complement to produce marked hemolysis of cells of the opposite group without apparent agglutination. If the hemolysis and/or its significance is not recognized, the incompatibility will be overlooked. Hemolysis should be avoided by inactivating the complement of serum by heating at  $56^{\circ}\text{C}$ . for fifteen minutes before performing the test.

*Proof of the ABO Blood Group*—Ultimate blood grouping errors will be markedly reduced if each test, performed by mixing the unknown cells with anti A and anti B serum, is confirmed by identifying the agglutinins in the unknown serum. This may be easily accomplished by inactivating the serum by heating to  $56^{\circ}\text{C}$ . for ten to fifteen minutes and testing against a 2 per cent suspension of A cells and a like suspension of B cells. The serum used for Kahn tests may be used. It is advised to perform the cell grouping on blood taken from the finger, and the serum grouping on blood obtained by venipuncture. The purpose of taking two samples is to provide a check on errors in labeling specimen tubes.

The results obtained with both tests in all four ABO groups are as follows

	Unknown Cells Plus		Unknown Serum Plus	
	Anti A Serum	Anti B Serum	A cells	B cells
Group O	—	—	+	+
Group A	+	—	—	+
Group B	—	+	+	—
Group AB	+	+	—	—

If the results of the two tests agree, the chance for error is extremely small. It is strongly recommended that all blood grouping tests be proved in this manner.

*Centrifuge Method for Blood Grouping and Crossmatching*—Blood grouping and crossmatching may be accomplished with greater speed and with equal or greater accuracy by the centrifuge method. This differs from the slide technique only in that the serum and cell mixtures are placed in test tubes, mixed and centrifuged at 500 to 1000 r.p.m. for one minute, gently resuspended, and read. As with the slide method all negative readings must be checked microscopically. It is not necessary to allow the serum and cell-suspension mixture to stand for any length of time before centrifuging. The usual sources of error such as excessively heavy or light cell suspensions and contamination, must be avoided when using this technique.

**RH INCOMPATIBILITY (Intragroup Reactions)**—Approximately 13 per cent of the white, 6 per cent of the Negro race and 1 per cent of the Chinese are Rh negative. These individuals do not have Rh antigen on their red cells and hence may build up anti Rh agglutinins when properly immunized. Anti Rh agglutinins are never present in the serum of nonimmunized humans. Immunization may occur as a result of (a) transfusion of Rh positive bloods into an Rh negative individual, or (b) an Rh positive fetus in an Rh negative mother.

The Rh agglutinogens are apparently not very potent antigens in humans. Thus, not every Rh-negative recipient of Rh-positive blood will be immunized, and even in those that are, it usually requires several transfusions before sufficient antibody is formed to cause reactions. The percentage of recipients who become immunized to a limited degree, so that they destroy transfused Rh-positive cells fairly rapidly but without apparent symptoms, is not known. Immunization of Rh-positive individuals by Rh-positive subtypes or by Rh-negative blood may occur but it is quite unusual.

The reaction following transfusion of Rh-positive blood into an immunized Rh-negative individual is hemolytic and, although usually milder, is comparable in every way to the reaction following A, B, O incompatibilities.

The first reaction to Rh positive blood in an individual immunized by repeated transfusions is usually relatively mild. The reactions usually increase in severity with subsequent transfusions and may finally result in a fatality. In the case of mothers already sensitized by an Rh positive fetus, the first transfusion may be fatal. Rh-negative recipients who have become immunized by the Rh antigen must be given Rh negative blood exclusively.

Ideally, every blood transfusion should be Rh compatible. When this is not possible, one must be on the alert for the slightest evidence of hemolytic reactions in patients receiving repeated transfusions. The anti Rh agglutinins are not always detectable even in the serum of a highly sensitized person and may be missed in the crossmatching test. Thus a patient who has had a hemolytic reaction with ABO compatible blood *must* be given Rh compatible blood. Transfusions must be delayed until Rh compatible blood is procured. Women who are or who have ever been pregnant must always be given blood of their own Rh type, since immunization may last for many years.

Determination of Rh type is done by testing the red cells against anti Rh serum. Rh-positive cells are agglutinated by anti-Rh serum.

Proof of Rh immunization may be obtained in most cases by testing the serum of the patient against known group O Rh-positive and O Rh-negative cells. The tests should be set up by mixing several drops of serum with a 2 per cent suspension of cells and incubating at 37° C for one hour. The test may then be read. If negative, they should be centrifuged for one minute at 1000 rpm, very gently resuspended and read again. Agglutination of O, Rh-positive cells and no agglutination of O, Rh-negative cells indicates the presence of anti Rh antibody.

Failure to agglutinate Rh-positive cells does not conclusively prove absence of anti-Rh agglutinins in the serum since Rh blocking antibody may be present and prevent agglutination of the specific cells when the test-tube method is employed. Blocker may be demonstrated

by adding a drop of active anti-Rh typing serum to the tube containing the patient's serum and the Rh-positive cells, incubating for thirty to sixty minutes and centrifuging for one minute at 1000 r p m. The tests are then read in comparison with a control set up with the same Rh-positive cells and anti-Rh typing serum but not containing the patient's serum. Failure of the anti-Rh typing serum to agglutinate the Rh-positive cells in the presence of the patient's serum, when the same cells are agglutinated in the control test, indicates the presence of an Rh blocking antibody and, by inference, the presence of anti-Rh agglutinins. This may often be proved by the following test.

If no antibody is detected in the tube tests, a third test should be performed on open slides. This is done by mixing one drop of the serum with two drops of whole oxalated O, Rh-positive blood and observing for agglutination. A control must be run with whole oxalated O, Rh-negative blood. If anti-Rh agglutinins are present, agglutination will usually occur on the test slide within a few minutes.

**2 Intravascular Hemolysis of Recipient's Cells**—Intravascular hemolysis of the recipient's cells may be produced by intravenous administration of distilled water, or in A, B or AB recipients by plasma or group O blood which contains excessively high titer anti-A or anti-B agglutinins.

Distilled water has been administered intravenously, by accident, in a few instances. In some cases where 1000 cc. were given over a period of an hour or more, no serious results were noticed. When given more rapidly, death has resulted.

The agglutinin titer of pooled plasma is not sufficiently high to produce significant hemolysis of the recipient's cells.

Use of group O blood for A, B and AB recipients is attended by the possibility of hemolysis of the recipient's cells when the agglutinin content of the transfused blood is excessively high. The wide use of group O blood for all patients in several war theaters has demonstrated that the incidence of severe reactions is very low. There have been no cases of anuria reported which have been proved to be caused by group O blood in the absence of Rh incompatibility. There have been a few instances where the administration of 500 cc. or less of group O blood to group A or AB patients has been followed by marked hemolysis of the recipient's red cells. In most of these, the hemolysis continued for a few days and the erythrocyte count dropped sharply. The incidence of undetected, less severe hemolytic reactions is not known.

In view of these facts, it is advised that group O blood be given to A, B and AB recipients only when the agglutinin titer is not excessively high. It is recommended that a single tube titration be done on all group O bloods to separate them into two groups. The low titered

blood may be given to anyone. The high titered blood should be reserved for O recipients.

The upper limit of agglutinin titer compatible with safety is not known and probably varies with different recipients. The technic of titration varies so greatly from one laboratory to another that it is almost useless to advise a limiting numerical titer. In the light of our present knowledge of the subject, it seems best to select a method and a titer which will label approximately 25 per cent of all O bloods as having a high agglutinin content. It is unlikely that 25 per cent of group O bloods are potentially dangerous, but, in view of the fact that many patients receive multiple transfusions, the titer for "Universal Donor" blood should be kept as low as possible.

3. **Intravascular Hemolysis of Compatible Donor Cells**—In vivo hemolysis of compatible donor cells may occur when the transfused blood has been stored too long or at too high a temperature. Fortunately, the results are rarely serious, however, bloods showing large amounts of hemoglobin in the supernatant plasma must not be transfused. Patients have been given a full 500 cc of over-age blood, which survived in the recipient's circulation not more than a few hours, without any apparent subjective symptoms. Obviously, this blood is of little benefit to the patient. When the transfused blood is promptly broken down, there will be free hemoglobin in the serum which will be converted to bilirubin in a short time. Clinical jaundice may be evident. The possible deleterious effect of hemoglobinemia upon the kidneys of a patient in shock may only be surmised. This complication may be avoided by the use of fresh or properly preserved stored blood. Blood drawn in plain citrate solution should be stored for not more than five days. Blood drawn in Alsever's solution\* or in acid citrate dextrose solution† may be stored for up to twenty one days. The temperature of storage must, at all times, be between 4° and 10° C. Higher temperatures decrease the post-transfusion survival. Lower temperatures, short of freezing, give good survival but tend to cause excessive precipitation of fibrinogen which may interfere with administration.

4. **Transfusion of Hemolyzed Blood**—Transfusion of hemolyzed blood may or may not produce severe reactions. There is insufficient data available on the subject but cases of fatal anuria have been reported to have resulted from such transfusions. The administration of hemolyzed blood is almost always accidental. It usually results when a refrigerator reaches subfreezing temperatures and freezes the blood which subsequently thaws and is given without observation of the hemolysis. Care must be taken to avoid such accidents.

\* Alsever's Solution (500 cc) Dextrose, 2.05 per cent, trisodium citrate 0.8 per cent, sodium chloride, 0.42 per cent.

† Acid Citrate Dextrose Solution (120 cc) Dextrose, 3 per cent, trisodium citrate, 1.34 per cent, citric acid, 0.47 per cent.

**Laboratory Evidence of Hemolytic Reactions**—Every transfusion reaction should be completely investigated and the cause determined if they are to be avoided in the future. The lines of investigation should include several laboratory tests

(1) Withdraw a sample of blood from the vein of the recipient within thirty minutes of the onset of the reaction. Use a clean, dry syringe. Separate cells and serum. The pretransfusion sample will serve as a control. If the patient had a hemolytic reaction from any cause, the serum may contain free hemoglobin or an increase of bilirubin which may be observed macroscopically. If the postreaction serum is free of hemoglobin and bilirubin, it may be assumed that the reaction was not the result of hemolysis.

(2) Withdraw a sample of blood from the patient approximately four hours after the reaction and test for bilirubin. Almost every hemolytic reaction is followed by an increase in serum bilirubin.

If either of the above tests gives any evidence of a hemolytic reaction, proceed to determine its cause.

(3) Recheck the blood group of the recipient and blood from the donor bottle.

(4) Recheck the crossmatching tests.

(5) Centrifuge a specimen from the donor bottle to determine the presence or absence of hemolysis.

(6) Determine the Rh type of the recipient and donor. It must be remembered that tests run on an Rh-negative patient who has received transfusions within a few weeks may show some Rh-positive cells although the majority are Rh negative. This possibility must be considered with each test.

(7) If the recipient is Rh-negative, test the pre-reaction sample of the recipient's serum for presence of anti-Rh agglutinins, using the test tube antibody test, the blocker test and the slide antibody test described previously.

(8) If the donor was group A, B or AB and received group O blood, titer the donor serum against the recipient's cells.

#### PYROGENIC REACTIONS

By definition, the term "pyrogen" means "fever-producing substance." Pyrogenic reactions are characterized by fever in test animals and fever or a chill followed by a fever in man. Such reactions may follow the introduction into the blood stream of foreign material, such as inspissated protein, dried blood, viable or nonviable organisms or the metabolic by-products of the growth of certain bacteria. Gram-negative organisms usually produce much more pyrogen than gram-positive organisms. There is no evidence that fungi produce pyrogen.

Tap water is usually derived from surface waters (lakes and rivers) where gram negative organisms thrive. Filtration of the surface waters



removes most of the particulate matter and chemical sterilization kills bacteria, but neither filtration nor chemical sterilization has any effect upon the metabolic by products (pyrogen) of the growth of bacteria. Proper distillation will render water pyrogen free provided the concentration of pyrogen in the predistilled water is not too great.

Freshly distilled pyrogen free water will remain pyrogen free only so long as it remains sterile. Following distillation, the water may become contaminated with pyrogen producing bacteria which may produce sufficient pyrogen within four hours so that even after subsequent sterilization the water will be pyrogenic. Accordingly, when distilled water is not sterilized within four hours of the time when it was distilled, it must be considered pyrogenic. Flasks of sterile, pyrogen free water must be considered pyrogenic four hours after the time they are opened.

Pyrogenic reactions will follow the use of blood, plasma or crystalloid solutions which contain pyrogens. However, in actual practice the great majority of this type of reaction are caused by pyrogens present in the accessory sets, particularly the recipient sets. The pyrogen may be inspissated plasma or dried blood, but it is most frequently metabolic by-products of the growth of bacteria in the sets which have become contaminated during or after use, or, when the sets have been properly cleaned in the unsterile water residual in the tubing after cleaning. Pyrogens tend to accumulate so that, if the sets are not properly cleaned after each transfusion, there may be a sufficient accumulation of pyrogen so that a particular set may cause chill and fever reactions each time it is used.

Pyrogen reactions may vary in severity from a slight temperature rise to chills, fever, cyanosis and marked prostration. The severity of the reactions depend upon the amount of pyrogen infused and the susceptibility of the patient. The reaction may start at any time during or after the infusion, but occurs most frequently a short time after the infusion has been completed. The rise in temperature may be 4 to 5° so that, if the patient's temperature is high before the infusion it may rise to a dangerous level. The temperature usually returns to the pre infusion level within four hours and, although the patient may become nauseated, vomit, void or defecate involuntarily, there is little danger of a fatal termination.

The occurrence of a chill during the transfusion of whole blood or red cells suspension is a signal to terminate the transfusion. This is imperative for the reason that the initial clinical manifestation of serious hemolytic reactions from the transfusion of incompatible ABO group blood or Rh type blood in previously immunized recipients can not immediately be differentiated from simple pyrogen reactions. A further reason is that contaminated parenteral fluids containing large amounts of pyrogens may cause mild or moderate reactions when

relatively small quantities are administered, but severe or possibly even fatal reactions when the entire amount is infused

*The common errors leading to the preparation of pyrogenic recipient sets are*

- (1) Insufficient cleaning of the rubber tubing and/or glass and metal parts
- (2) Delay in cleaning sets so that large amounts of pyrogen develop which may not be removed by the method in use for cleaning sets
- (3) Rinsing with supposedly pyrogen-free water which has become contaminated
- (4) Allowing properly cleaned and rinsed sets to stand for longer than four hours before sterilization

## DIRECTIONS FOR CLEANING AND STERILIZING DONOR AND RECIPIENT SETS

### I Rubber Tubing

#### A New tubing

- 1 Place the tubing in 5 per cent sodium carbonate, starting with one end and lowering it in such a manner as to fill the lumen completely
- 2 Boil for 15 minutes in the 5 per cent sodium carbonate solution
- 3 Rinse thoroughly with tap water
- 4 Rinse with at least 50 cc of pyrogen free saline
- 5 Sterilize within four hours

#### B Used rubber tubing

Care of used rubber tubing will vary, depending upon the time elapsed between use and cleaning. If the set is not cleaned within four hours of the time it was used, it must be considered contaminated with bacteria and the by products of bacterial growth.

*Tubing cleaned within four hours of use* may be treated as follows.

- 1 Rinse thoroughly with the tap water. Roll and crush between one's hands, and stretch the tubing several times between rinsings to remove all clots adherent to the inner lining
- 2 Rinse with at least 50 cc of pyrogen free saline
- 3 Wrap and sterilize within four hours

Ordinarily, it will be possible to treat donor sets as described above

*Tubing not cleaned within four hours of use*

Such tubing is potentially contaminated and must be thoroughly rinsed with tap water to remove all blood clots and then treated as new tubing. It is best to make it a routine to treat all recipient sets in this manner

### II Glass Parts

- 1 Rinse with tap water
- 2 Immerse in concentrated nitric acid for four to six hours.
- 3 Rinse in tap water
- 4 Rinse in ample quantities of pyrogen free distilled water

### III Stainless Steel Filters

Treat as glassware

## IV Stainless Steel Valves

- 1 Wash thoroughly with tap water
- 2 Rinse with ample quantities of pyrogen free distilled water
- 3 Place 1 or 2 drops of CP glycerin on the core of the valve. Screw the proper valve head in the proper valve. Do not screw the valve tight, but leave one half turn open for sterilizing

## V Needles

- 1 Wash with tap water
- 2 Rinse with pyrogen free distilled water

Sterilization of assembled donor and recipient sets must be accomplished within four hours of the time they are cleaned. The sets should be wrapped in muslin and autoclaved at 120° C for twenty minutes. If the sets are not used within seven days, they should be broken down, re washed, wrapped and sterilized.

## ALLERGIC REACTIONS

Allergic manifestations may occur during or following transfusion of whole blood, plasma, and even human serum albumin. This type of reaction may be manifested as angioneurotic edema, urticaria, asthma and may cause edema of the larynx which may have a fatal termination.

Urticaria is, by far, the most common complication. It responds readily to subcutaneous administration of 0.3 mg. doses of epinephrine and produces no serious results. The appearance of urticaria does not necessarily mean that the infusion must be stopped, but the patient must be treated promptly. Asthma and signs of laryngeal edema indicate prompt discontinuance of the infusion and treatment with epinephrine.

Allergic reactions, presumably, are due to a response on the part of the recipient to allergens contained in the blood of the donor. For this reason, it has been advised to use fasting donors when practical. It is also possible to passively transfer sensitivity by blood or plasma transfusion. The recipient who has been passively sensitized by a transfusion of blood or plasma from an allergic individual may show an allergic response if he contacts the specific allergen. Passively transferred allergy persists for, at least, several weeks. For this reason, it is advised that individuals suffering from major allergies not be used as donors.

## CIRCULATORY OVERLOAD

Blood may be transfused very rapidly when the patient's condition is associated with a reduced blood volume. When blood is administered to a patient in severe shock, it is not only permissible but advisable that it be given at a rate of approximately 50 to 75 cc. per minute.

When the recipient is not in shock, there is little justification for an extremely rapid rate of transfusion. In such cases, it is advised to start the infusion at a rate of approximately 5 cc. per minute for the first twenty minutes and then increase the rate so that procedure may be finished in approximately forty five minutes. When this practice is followed, most hemolytic reactions will be detected before more than

100 to 200 cc of blood have been given and the transfusion may be stopped at that point

In busy hospital wards it is not uncommon for a patient to receive too much fluid and/or blood intravenously in too short a time. There have been many instances of edema of the lungs following rapid infusion of large volumes of blood, plasma and crystalloid solutions. There are no hard and fast rules as to the amount of fluids each patient may take, but it is advised that the attending physician bear in mind the possibility of exceeding the capacity of the patient's circulatory system when administering intravenous fluids. Elderly patients and those suffering from myocardial disease whose blood volumes are normal may not tolerate an increased blood volume without circulatory overload, especially when the increase is rapid. This is also true in the case of patients with renal damage who are unable to clear large amounts of water through the kidneys. In such cases, caution is advised and the rate of flow of parenteral fluids, particularly blood and plasma, should be adjusted to the slowest practical rate.

#### EMBOLIC REACTIONS

Blood and plasma must be filtered immediately prior to administration to remove any particles which may be present. This practice is so widely accepted that there are few reports of untoward reactions following administration without filtration.

Air emboli may produce fatal results. Air may be introduced into the circulation if the recipient tubing is not completely filled with blood before venipuncture is accomplished. More often air emboli result when blood is forced in under pressure. The use of pressure has found increasing popularity and is justified in many instances. *It must never be resorted to unless a responsible person is in constant attendance.* Pressure must be released as soon as the bottle of blood is nearly empty. Serious results have attended instances when air pressure was applied, the blood run in and the remaining air in the bottle allowed to flow into the recipient's vein.

#### II TRANSMISSION OF DISEASE

Of all the diseases transmitted by blood transfusion, infectious hepatitis, malaria and syphilis are the most common.

**Infectious Hepatitis**—It has been definitely established that infectious hepatitis may be transferred from one person to another by blood transfusion. It has not been determined for how long a person remains infectious after apparent recovery from this disease. Recent data strongly suggest that the blood may contain the causative organism for many months. There is no evidence that refrigeration destroys the causative agent. In view of these facts, no person who has had infectious hepatitis should be used as a blood donor.

**Malaria**—Malaria has been transmitted by blood transfusion. There

are no criteria for complete cure of malaria. The parasites will remain viable in blood stored at refrigerator temperature for, at least, a few days. The period of storage to insure death of all parasites is not known. Accordingly, persons who have had malaria should not be used as blood donors.

**Syphilis**—Syphilis has been transmitted by blood transfusion. It may be transmitted in the early stages before the serological tests are positive. It is quite probable that refrigeration at 4 or 5° C for one to three days will render the organisms incapable of producing the disease.

It is recommended that blood not be taken from persons having a history of genital sores or discharges within six months. A Kahn and/or Kolmer test must be performed on all bloods to be used for transfusion. Individuals who have or have had syphilis should not be used as blood donors. When possible, blood should be stored at 4 or 5° C for at least twenty-four hours prior to transfusion.

**Other Diseases.**—Many other diseases may be transmitted if blood is drawn during the illness. Thus relapsing fever, ratbite fever, most of the virus and rickettsial diseases, and many bacterial diseases fall in this group. There are relatively few instances recorded of passive transfer of this group of diseases since individuals suffering from them are obviously not good prospective blood donors. The possibility of such transfer must be borne in mind, particularly when it is known that the donors have been exposed to infection.

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## PREOPERATIVE AND POSTOPERATIVE SEDATION

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THE problems of preoperative and postoperative sedation have been subjects of clinical and investigative studies since morphine was first used as a preanesthetic drug by Lorenzo Bruno of Turin in 1850. During the last ninety-five years many single drugs and combinations of narcotics, sedatives and belladonna-like drugs have been used before operation in an attempt to decrease reflex irritability, produce psychic sedation, suppress secretory activity and minimize the dangers of toxic reactions from the anesthetic drugs.

### PREMEDICATION

**Analgesics.**—*Morphine sulfate* is the most widely used of all preanesthetic drugs. The dosage varies from  $\frac{1}{12}$  grain (0.0054 gm.) in adolescent children and debilitated patients, to  $\frac{1}{4}$  grain (0.016 gm.) in healthy robust adults. *The amount given subcutaneously should be that amount which will produce the desired effect without excessive depression of the vital functions.* An overdose of morphine will cause respiratory depression with resultant increase in carbon dioxide threshold; the respiratory rate and depth are decreased; and susceptibility to chemical and nervous stimuli is altered. Small children do not tolerate therapeutic doses of morphine.<sup>18</sup>

With the intravenous administration of morphine, the maximum subjective depression is attained within three to five minutes. However, the maximum analgesic effect requires twenty minutes. Seevers and Pfeiffer<sup>20</sup> state that neither the degree nor the duration of analgesia is as great from intravenous as from hypodermic administration. There is greater subjective depression for a short period, but there is a less pronounced and less prolonged elevation of the pain threshold. If morphine is given too rapidly in intravenous administration, the narcotic action might be so great that the patient will complain of feeling very weak with the sensation of impending loss of consciousness. When given intravenously, morphine is dissolved in 2 to 5 cc. of sterile distilled water and given slowly over a period of two to three minutes to avoid toxic manifestations. Pearman<sup>22</sup> recommends the use of intravenous morphine especially for patients suffering severe pain because of the rapidity with which analgesia is produced. This route is most advantageous for use in the emergency case where there

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is but a short interval between sedation and operation. Morphine in doses of  $\frac{1}{8}$  grain (0.008 gm) to  $\frac{1}{6}$  grain (0.011 gm) can be given intravenously without fear of toxic reaction.

The sublingual route of administration has been suggested in emergencies where it is impossible to administer morphine hypodermically or intravenously. Walton<sup>32</sup> maintains that the majority of drugs do not penetrate the oral mucosa in significant amounts. Conclusive evidence is not available as to the degree of absorption by the oral mucosa and so this route of administration is not recommended.

*Pantopon* (omnopon) is a composite of the pure alkaloids of opium and contains about 50 per cent morphine. This drug given in doses of  $\frac{1}{6}$  grain (0.011 gm) to  $\frac{1}{2}$  grain (0.022 gm) is satisfactory when used as a preanesthetic narcotic agent. It is not satisfactory as a substitute for morphine in patients who have shown morphine sensitivity.

*Dilaudid* (dihydromorphinone hydrochloride) is a satisfactory substitute for morphine and is administered in  $\frac{1}{32}$  grain (0.002 gm) to  $\frac{1}{24}$  grain (0.003 gm) doses. From the work of SeEVERS and Pfeiffer<sup>33</sup> it is shown that ninety minutes is required as the time interval after subcutaneous injection for maximum elevation of the pain threshold. Its action is fairly prolonged and the subjective depression is less than with morphine. This drug has been claimed to be superior for the relief of chronic pain.

*Demerol* has been gaining wide popularity because of its morphine and atropine-like actions without the respiratory depression of morphine. Demerol, a phenylpiperidine derivative, was synthesized by Eislab and Schaumann in 1939. Its central nervous system depression is less than that of morphine. However, its analgesic action is said to be almost as effective. In addition to the analgesic quality of morphine, it possesses the antispasmodic action of atropine. Weinstein<sup>34</sup> reports that demerol has a distinct relaxing action on the smooth muscles of the bowel, the uterus, the bronchial tree and the urinary bladder. It causes a drying effect with suppression of secretions from mucous membranes. Rovenstine and Batterman<sup>35</sup> have found that 100 mg of demerol is equivalent to  $\frac{1}{4}$  grain (0.016 gm) of morphine. Its action is of short duration and may be effective for only two hours. The drug is rapidly broken down, probably in the liver. Batterman and Himmelsbach<sup>3</sup> are of the opinion that prolonged use of demerol may lead to habituation and, in order to avoid this, amounts greater than 150 mg every three hours should not be given. Rovenstine and Batterman<sup>36</sup> recommend the use of demerol and scopolamine as preanesthetic medication, having found that patients receiving demerol alone were less drowsy and more alert than those receiving demerol and scopolamine.

**Belladonna like Drugs.**—The initial dose of narcotics given preoperatively is usually accompanied by a small dose of either atropine sulfate

or scopolamine hydrobromide for the purpose of inhibiting secretory activity and overcoming, to some extent, the depressant effect of the narcotic Guedel<sup>9</sup> points out that *atropine* decreases the narcotic effect of morphine in such a ratio that morphine sulfate, grain  $\frac{1}{4}$  (0.016 gm), and atropine sulfate, grain  $\frac{1}{150}$  (0.0004 gm), have about the same depressant action as a single dose of morphine sulfate, grain  $\frac{1}{6}$  (0.011 gm). Dill<sup>6</sup> recommends the use of atropine sulfate because of its parasympathetic inhibitive action tending to decrease the incidence of laryngospasm. This drug also tends to decrease gastrointestinal motility. The maximum effect of atropine following subcutaneous injection is reached in one to one and one half hours. This drug can be given intravenously if a more rapid action is desired. The ordinary therapeutic doses of atropine must be decreased if given intravenously in order to avoid the signs of overdose which include flushing of the face, dry mottled skin, rapid increase in body temperature, tachycardia and hallucinations.

*Scopolamine* (hyoscyne) is a parasympathetic inhibitor drug used to suppress secretions from mucous membranes and as an antispasmodic. According to Goodman and Gilman,<sup>8</sup> scopolamine is a primary depressant and therapeutic doses cause drowsiness, fatigue and dreamless sleep. From the studies on man, Waters and his co-workers<sup>34</sup> show that scopolamine does not increase the medullary depressant effects of morphine but is antagonistic to them. They claim that the depressant effects of morphine sulfate are combated by simultaneous administration of scopolamine hydrobromide. These studies do not support the belief that scopolamine is a respiratory depressant. Waters<sup>33</sup> found that the ratio of 25:1, scopolamine to morphine, was ideal and that the optimum time for premedication was one and one-half hours. The adult dose of scopolamine is  $\frac{1}{200}$  grain (0.00032 gm) to  $\frac{1}{100}$  grain (0.00065 gm). Guedel<sup>9</sup> maintains that scopolamine is directly a metabolic stimulant but reduces metabolism by reducing emotional excitement. It is definitely a psychic sedative and is effective in quieting a patient's emotional disturbance. Variable results are obtained with scopolamine since certain patients manifest excitement and delirium. Those in favor of its use recommend that it must be obtained from a reliable manufacturer and not be stored for long periods. Hewer<sup>10</sup> writes that the variable effects are due to the fact that scopolamine contains a levorotatory form which has a sedative and amnesic effect, a dextrorotatory form which has a stimulant or excitement effect and two isomeric alkaloids with variable effects. The presence of pain may be the cause of the excitement since sedatives which do not have analgesic qualities may produce excitement in uncontrolled pain.

**Sedative or Hypnotic Drugs—Barbiturates** are used to produce a sound sleep the night before operation and to allay fear and apprehension during the few hours before operation. They are used as



prophylaxis before the use of a local anesthetic agent to forestall toxic reaction. Barbituric acid derivatives are not substituted for morphine since they are not analgesics. If excitement does occur during the use of barbiturates postoperatively, it is most likely due to pain and morphine will relieve it. The short acting barbiturates are employed in preoperative medication. Pentobarbital (nembutal), ethyl methyl butyl barbituric acid is the one preferred by us since it produces the least amount of restlessness and excitement. Pentobarbital grains  $1\frac{1}{2}$  (0.1 gm), is administered orally at bedtime the night before operation and repeated in the morning two hours before the anticipated time of operation. *Adrian's*<sup>1</sup> investigation reveals that the barbituric acid derivatives are rapidly absorbed from the small intestine by oral route and from the large bowel by rectal route. The maximum hypnotic effect is reached in one hour and the duration of action is two and one half to five hours. If poor absorption is anticipated as following an injury, or in shock, the intramuscular route may be employed using the sodium salt. Seconal (sodium propyl methyl carbonyl allyl barbiturate), grains  $1\frac{1}{2}$  (0.1 gm), and sodium amytal (sodium ethyl isoamyl barbiturate), grains 3 (0.2 gm), are used by many anesthetists and surgeons. Delvinol sodium (vinbarbital sodium), grains 3 (0.2 gm), has been recommended by Lorhan.<sup>17</sup>

In large doses barbiturates cause a definite depression of the respiratory center. This in combination with the depressant effect of morphine, may tend to increase the induction time of inhalation anesthesia. There is little change in metabolism in hypnotic doses. Intracranial pressure is probably decreased. During hypnosis the heart rate is not changed but tachycardia may develop in anesthetic doses.

**Basal Narcosis**—The use of basal narcosis is time consuming and dangerous because of the possibility of profound respiratory depression requiring prompt and complete resuscitative measures. Marston<sup>10</sup> writes that the effects of shock in deep basal narcosis are increased and recovery may be retarded. The drugs for basal narcosis are mentioned but not recommended except for the careful use of avertin in young children undergoing endoscopy.

**Avertin** (tribromethanol) with amylene hydrate was introduced as an anesthetic by Drisberg in 1926, and has been used rectally as a basal anesthetic for hypnosis. An average dose of 80 mg per kilogram with a range of 50 to 100 mg per kilogram of body weight has been used rectally, one half hour before operation being administered in the patient's room. Approximately 95 per cent of the drug is absorbed in the first twenty five minutes. The average duration of hypnosis is two and one half hours. Tribromethanol is conjugated in the liver with glucuronic acid and excreted in the urine, while the amylene hydrate is eliminated unchanged in the lungs and kidneys. Tribro

methanol causes marked depression of the cortex, respiratory center and vasomotor center with a decrease of 20 per cent or more in blood pressure. Because of the possibility of marked respiratory depression, there are dangers associated with its use. It is definitely contraindicated in shock, hepatic and renal disease, colitis and enteritis, and hypothyroidism.

The well known toxicity of paraldehyde precludes its use as a basal narcotic agent.

Preanesthetic drugs and anesthetic agents have a marked effect on the normal blood count and blood concentration. Morphine produces a leukocytosis which lasts for twenty-four hours. Atropine and scopolamine cause a slight increase in leukocytes. Ether anesthesia causes a contraction of the spleen and the loss of fluid with a subsequent increase in erythrocytes. Searles<sup>27</sup> has concluded that morphine and preoperative intravenous fluids protect animals against concentration of blood during ether anesthesia. Barbiturates cause a decrease in the number of red cells and may increase the white cells. They cause a dilatation of the spleen and a resultant dilution of the blood. From the experiments of Pender and Lundy,<sup>23</sup> changes of the concentration of the erythrocytes in the peripheral blood were largely due to changes of the volume of the spleen. Ether anesthesia caused a contraction of the spleen of the dog while sodium pentothal caused a dilatation of the spleen. Searles<sup>27</sup> has found that the spleen increases enormously in size under sodium amytal anesthesia and there is a marked decrease in the erythrocyte count, hemoglobin and cell volume. Splenectomy abolished completely the reduction of erythrocytes. These factors are important in the development of shock, since the normal spleen acts as a reservoir of blood ready to supply its own transfusion in case of an emergency.

**Inhalation Anesthesia.**—Premedication, when inhalation anesthesia is to be used, consists of pentobarbital (nembutal), grains  $1\frac{1}{2}$  (0.1 gm.), given orally at bedtime the evening before operation and repeated the following morning, two hours before the anticipated time of operation. Morphine and atropine in proper dosage are administered hypodermically one and one-half hours preoperatively. The time interval is stressed since the induction of inhalation anesthesia is usually begun twenty minutes before the approximate time of operation and the morphine will have had at least sixty minutes for absorption and maximum effect on the respiratory center. The full degree of respiratory depression is present prior to the induction of anesthesia. If marked depression does occur as in a sensitive individual, it is wise to change the type of anesthesia, provided another is suitable for the operative procedure. If another technic such as local or spinal is not advisable, postponement of the elective operation should be considered. On the

other hand, if insufficient premedication has been given and the patient is very alert and apprehensive, morphine, grain  $\frac{1}{8}$  (0.008 gm), intravenously may be given before the administration of the anesthesia.

According to Guedel,<sup>9</sup> the metabolic state of the patient will determine his resistance to anesthesia. The curve of the metabolic rate is parallel to the oxygen demand and the reflex irritability. The factors governing the metabolic rate are (1) age—the older the individual the lower the rate, (2) weight—the very muscular as compared to the thin asthenic individual, (3) emotional state—fear and apprehension causing a temporary preanesthetic increase in metabolic activity, (4) pain—increasing the irritability of the nervous system, (5) fever—for each degree of fever, there is about 7½ per cent increase in metabolic rate, (6) endocrine disorders such as hyperthyroidism or hypothyroidism.

The induction of inhalation anesthesia is smoother and is accomplished with the least amount of excitement when the premedication is adequate. An attempt must be made to relieve fear of suffocation when the mask is placed on the face. The anesthetist should encourage the patient to breathe regularly and assure him that everything is as it should be. The reflex irritability will govern the degree of excitement manifested during the induction stage. Morphine, in proper dosage, will cause depression of all forms of sensory stimuli especially pain, fear and apprehension and the disagreeable irritating odor of an anesthetic agent such as ether. Atropine will suppress secretions from salivary glands and mucous membranes. It is a mild respiratory stimulant and will offset the depression of morphine.

Respiratory depression must not be marked prior to an ether anesthesia. The respiratory rate and minute volume exchange governs the rate of absorption of ether. When depression is marked, the slow shallow respiratory excursion will not allow a sufficient alveolar ether tension necessary for smooth rapid induction of anesthesia. With the use of weaker anesthetic agents such as nitrous oxide and ethylene, for operations of short duration heavier premedication may be necessary.

It has been suggested that death during the induction stage is due to ventricular fibrillation caused by excessive adrenalin in the circulation as a result of emotional excitement. Robbins<sup>10</sup> believes that hyperactivity of the sympathetic system and the increased output of epinephrine are factors which predispose to ventricular fibrillation. Barbiturates should be included in the premedication to depress the sympathetic nervous system.

**Thoracic Surgery**—It is paramount that preanesthetic medication in thoracic surgery does not cause respiratory depression and that it wear off sufficiently by the end of operation to afford rapid reaction. Maier<sup>11</sup> states that oversedation with respiratory depression is unfav-

orable for a major thoracic operation Heavy premedication will delay the reaction time causing prolongation of cough reflex depression Every effort should be made to clear the tracheobronchial tree of all secretion prior to, during, and immediately following operation It must be remembered that after the operation the patient has the combined depressive effects of the preanesthetic medication, anesthetic, and shock of operation Recovery from pentobarbital (nembutal) may take several hours, so this drug is used in minimal doses or completely eliminated from the preoperative medication Himba and Currier<sup>12</sup> in their studies of the effect of morphine, atropine and scopolamine on the bronchi have shown that scopolamine-morphine in the ratio of 25:1 has one-half the depressant effect upon the raising of bronchial secretions as morphine and atropine In their studies on a woman with bronchopleurocutaneous fistula, they used comparable doses of scopolamine, grain  $\frac{1}{100}$  (0.00065 gm), to atropine, grain  $\frac{1}{50}$  (0.0013 gm) It is not justifiable to draw conclusions on the basis of a study in which such a large dose of atropine was used Atropine in large doses may be responsible for the drying of secretions Atropine, grain  $\frac{1}{150}$  (0.0004 gm), is usually sufficient Morphine causes a depression of the cough reflex and of ciliary action Demerol may have an advantage over morphine in thoracic surgery because of its less pronounced effect on the respiratory center

**Obstetrics**—The use of sedatives and narcotic drugs is not recommended for obstetrical patients within a period of two hours preceding delivery because of depressant effect on the fetus Patients who are to undergo cesarean section receive only a small dose of atropine sulfate,  $\frac{1}{200}$  grain (0.00032 gm) intravenously, prior to the induction of anesthesia

**Brain Surgery**—Morphine causes an increase in intracranial pressure and is claimed to be contraindicated in brain surgery It also produces respiratory depression with a decrease in respiratory rate and minute volume exchange As a result, there is a tendency to cerebral anoxia which predisposes to an increase in intracranial pressure Prior to an inhalation anesthesia,  $\frac{1}{150}$  grain (0.0004 gm) of atropine is usually sufficient If a sedative is required, pentobarbital (nembutal), grain  $1\frac{1}{2}$  (0.1 gm), may be administered orally two hours preoperatively The sodium salt may be administered intramuscularly if the patient is comatose and hard to handle

**Intravenous Anesthesia**—Pentobarbital (nembutal), grains  $1\frac{1}{2}$  (0.1 gm), is given orally the evening before and two hours before the scheduled time of operation Morphine and atropine are administered hypodermically, one and one half hours preoperatively Morphine grain  $\frac{1}{8}$  (0.008 gm) to grain  $\frac{1}{6}$  (0.011 gm) is usually sufficient Morphine and pentothal are synergistic An adequate dose of morphine will lessen the amount of pentothal required for anesthesia

Overmedication with morphine will cause respiratory depression which will be further increased by pentothal. If the patient is markedly depressed and can be aroused only with difficulty, a troublesome induction with pentothal can be anticipated because of the combined effects on respiration. Satisfactory anesthesia may not be attained. Atropine, grain  $\frac{1}{150}$  (0.0004 gm), is most important as a prophylaxis for laryngospasm. If a longer period than two and one half hours has elapsed since the administration of atropine, it is wise to repeat the dose intravenously before pentothal induction. The use of atropine prior to intravenous anesthesia cannot be overemphasized. If laryngospasm does occur during pentothal anesthesia, atropine, given intravenously in addition to positive pressure lung inflations, will usually relieve the condition.

**Spinal Anesthesia**—Pentobarbital (nembutal), grains  $1\frac{1}{2}$  (0.1 gm) is administered orally the evening before and one and one half hours before operation. The peak of hypnotic action is usually reached in one hour and is effective to a full degree for two and one half hours. Adequate psychic sedation is present for a short period preoperatively during spinal puncture and throughout operation. The barbiturates are also important as protection against cardiac irregularities caused by ephedrine which is used almost routinely just prior to spinal puncture. Morphine and atropine in proper dosage is administered by hypodermic, one hour before the scheduled time of operation. Morphine produces subjective depression which is important in relief of fear, anxiety and apprehension during spinal anesthesia. Moderate psychic sedation should exist but not to the point where the patient is uncooperative. Intravenous morphine may be administered during the course of the operation when the spinal anesthesia shows signs of wearing off and the patient is complaining of discomfort or burning sensation. This will help to prolong the spinal anesthesia for another fifteen minutes if the surgery should be in its closing stages. If it is necessary to supplement spinal anesthesia with intravenous pentothal, morphine will decrease the amount of pentothal required.

Atropine, grain  $\frac{1}{150}$  (0.0004 gm), should be included in the premedication before spinal anesthesia for gastrointestinal surgery. Atropine causes decrease in the motility and emptying time of the stomach and intestines. Morphine decreases the activity of the stomach and intestines. The combined effect will tend to relieve increased peristaltic activity and movements produced by spinal anesthesia. The end result is a quieter gastrointestinal tract, a condition appreciated by the surgeon.

Ephedrine, grain  $\frac{3}{8}$  (0.024 gm), is administered just prior to spinal puncture. It is a sympathomimetic drug used to counteract fall in blood pressure associated with spinal anesthesia. Ephedrine is mixed with equal amounts of 1 per cent procaine. This is used to make the

skin wheal in the selected interspace. A second portion is injected into the intraspinal ligament. Ephedrine is a long acting sympathetic stimulator with sustained pressor effect and may be given when a fall in blood pressure is anticipated. A preanesthetic blood pressure should be taken. If it is high as in the older age group and in patients with arteriosclerosis, a small dose of 10 to 15 mg. may be used. Additional small doses may be given intravenously in order to sustain blood pressure at its normal level. It is important that ephedrine be used cautiously because of its effect on cardiac muscle. If the preanesthetic blood pressure is below 100 mm. of mercury it may be helpful to administer 15 mg. of ephedrine intravenously and check the blood pressure ten minutes later. If it is then above 100 mm., it is deemed safe to proceed with the spinal anesthesia. However, if blood pressure should persist below 100 mm. of mercury, a change in anesthesia should be considered. If nausea associated with a fall in blood pressure occurs ephedrine is repeated intravenously after the spinal has been given. A dose of 15 mg. of ephedrine may be given intravenously without an alarming rise in blood pressure.

**Local and Regional Nerve Block Anesthesia**—Pentobarbital (nembutal) grains  $1\frac{1}{4}$  (0.1 gm.), is given the evening before operation and one and one half hours preoperatively. Barbiturates are useful to relieve fear, anxiety and nervousness associated with this type of anesthesia. With proper premedication a nervous individual may be satisfactorily prepared for nerve block anesthesia. The barbiturates are important in offsetting toxic manifestations of local anesthetic agents. Morphine and atropine are administered hypodermically one hour before operation. Morphine will exert an analgesic effect which reduces pain associated with insertion of the needle. Heavier premedication may be necessary for the more painful nerve blocks such as deep cervical block and transsacral caudal block. It is not wise to overpremedicate since too much depression causes restlessness and lack of cooperation. Lundy<sup>18</sup> writes that "Lack of cooperation by the patient during local, regional or spinal anesthesia is normally due to intoxication from preliminary medication or insufficient dose." Atropine is included in the preanesthetic medication because of the possible use of intravenous pentothal as a supplement.

Epinephrine is included in most local anesthetic solutions. Four to six drops of a 1:1000 solution of epinephrine in 100 cc. of the anesthetic solution is sufficient to produce vasoconstriction and to prevent rapid absorption of the local anesthetic agent. By retarding absorption it probably aids in decreasing the toxic effects and also tends to prolong anesthesia. This drug should be omitted in cases of hypertension, hyperthyroidism and coronary heart disease. It is not included for digital blocks because of the possible production of vasospasm with resultant endarteritis obliterans and gangrene.

**Ambulatory Patients**—Premedication should be used cautiously in patients who are to return home after minor operations. If the anesthetic and operation are such that the patient is ambulatory postoperatively, heavy premedication will not allow him to return home with safety. Because of their prolonged action, the barbiturates should be avoided in these patients. Morphine may be used intravenously in small amounts to lessen fear and anxiety. Narcotic action is of shorter duration by this route of administration, thus allowing the patient to become ambulatory within a short period of time.

**Emergency Operations**—Premedication may be administered intravenously for emergency operations when there is a comparatively short period of time in which to prepare the patient. If inhalation or intravenous anesthesia is to be used, the stomach must be emptied by induced vomiting or gastric lavage. The possibility of vomiting, with aspiration of vomitus into the tracheobronchial tree, is a grave danger during inhalation or intravenous anesthesia. If this occurs during intravenous anesthesia, there is an associated laryngospasm because of the hyperactive pharyngeal and laryngeal reflexes associated with light pentothal anesthesia. With the first gasping type of inspiration under these circumstances, aspiration of food particles into the tracheobronchial tree may occur. Unless this material is immediately removed, respiratory obstruction with resultant asphyxia may ensue.

Morphine sulfate, grain  $\frac{1}{8}$  (0.008 gm) to grain  $\frac{1}{4}$  (0.011 gm), and atropine sulfate, grain  $\frac{1}{200}$  (0.00032 gm) to grain  $\frac{1}{50}$  (0.0004 gm), are given intravenously. Within fifteen to twenty minutes this premedication has reached its maximum effect and the patient is ready for the reception of the anesthetic agent. This routine should apply in all types of anesthesia in order to obtain suitable psychic sedation and the necessary prophylaxis to counteract any possible undesirable reactions due to the anesthetic agent.

**Premedication in Shock**—There are dangers associated with the hypodermic administration of morphine in a shocked individual. Because of impaired peripheral circulation there is a slow absorption of the morphine and maximum effect will not be attained prior to the induction of anesthesia. Hypodermic administration of morphine will not produce satisfactory relief of pain in a shocked individual, marked anxiety and fear will be present. The induction of an inhalation anesthetic will be difficult and prolonged. With the improvement of circulation as the result of shock therapy, absorption and respiratory depression may occur at a time when the anesthetic agent is exerting its depressing effect. If morphine and atropine are administered intravenously, the possibility of delayed absorption is eliminated.

Seeley and his co-workers<sup>24</sup> have found that if sodium amytal is used alone or given preliminary to ether anesthesia in the dog, there is a delay in the onset of shock and the time of death after trauma.

and exposure of the intestines From the work of Anderson and Essex<sup>9</sup> they concluded that morphine sulfate did not delay the onset of shock or death in animals under ether anesthesia, and that when morphine was combined with atropine or pentobarbital sodium, or both, the morphine reduced the effectiveness of the other drugs They found that atropine was the most effective of the preanesthetic drugs in delaying the onset of shock or death under ether anesthesia Elman<sup>7</sup> has inferred that large doses of morphine, when used in the absence of pain, may increase the early mortality of severe human burns The careful use of morphine is most important in shocked individuals

### POSTOPERATIVE MEDICATION

**Postoperative Sedation**—During the first twenty-four hours after operation there is the greatest need for morphine Administration must be carefully controlled, being given in doses sufficient to control pain but not large enough to produce profound respiratory depression The incidence of atelectasis and bronchopneumonia will be reduced if respiratory depression and suppression of the cough reflex are avoided The patient must not be allowed to remain quiet for any length of time The promiscuous use of morphine as a routine dose every four hours will increase the incidence of postoperative complications and prolong the recovery period After the first twenty four hours, a smaller dose of morphine or the substitution of codeine is normally sufficient for the relief of pain Oversedation will mask the early signs and symptoms of postoperative complications Krieg<sup>15</sup> has used the application of ice caps to the operative site for the control of postoperative pain, as a substitute for narcotic drugs, either in whole or in part Barbiturates will not relieve restlessness in the presence of pain Scopolamine is useful in the treatment of toxic psychosis to control the manic stage Atropine is not included in the postoperative medication because of its drying effect on bronchial secretions

**Nausea and Vomiting**—Postoperative nausea and vomiting is a serious complication requiring the administration of intravenous fluids to prevent dehydration An adequate daily fluid intake must be maintained It is a recognized fact that the vomiting center is stimulated by morphine and this drug may be the cause of nausea and vomiting in certain cases Codeine in sufficient dosage, hypodermically, may produce satisfactory analgesia without the undesirable effect of nausea and vomiting Steele<sup>21</sup> recommends the determination of a suitable narcotic prior to an elective operation in an attempt to eliminate unnecessary postoperative nausea and vomiting

**Gas Pains and Constipation**—During the first twenty four postoperative hours, there is decreased motility of the gastrointestinal tract due to the anesthetic and operative trauma of the intestines during abdominal surgery Morphine has the undesirable effect of decreasing the ac-



tivity of the stomach and intestines. Gas accumulates especially in patients who have a tendency to air swallowing. When the intestines recover some peristaltic activity there is an attempt to move this gas along. Gas pains are experienced with beginning peristaltic activity and morphine will tend to exaggerate and prolong them. Periods of decreased intestinal activity due to morphine are followed by an attempt on the part of the intestine to recover its peristaltic activity. In addition to decreasing intestinal activity, morphine causes a decrease in intestinal secretions and a slowing of the advancement of material through the bowel, with resultant constipation. Hand and Audin<sup>11</sup> recommend the use of morphine sulfate, grain  $\frac{1}{8}$  (0.008 gm) and prostigmine, grain  $\frac{1}{320}$  (0.0005 gm), subcutaneously every four hours, as necessary for pain. A small dose of morphine lessens the incidence of undesirable effects associated with the employment of larger doses.

**Abdominal Distention**—Abdominal distention may vary in degree from mild flatulence to a paralytic ileus. The prophylaxis and early treatment of this condition is important. Christopher<sup>5</sup> includes under prophylaxis the avoidance of preoperative purgation and catharsis, starvation with respect to food and water, undue intestinal trauma, air swallowing and postoperative retching and vomiting. Prostigmine methanesulfate, a synthetic compound, is a parasympatheticomimetic drug causing an increase in intestinal activity. It is a drug which is similar to physostigmine or eserine in its action and effectiveness but safer because of the lack of undesirable side effects. In therapeutic doses prostigmine will increase the tone of the intestine and so aid in the prevention and treatment of distention. Prostigmine is administered hypodermically in doses of  $\frac{1}{250}$  grain (0.00025 gm) every three hours for four to six doses postoperatively. If the distention progresses and is uncontrolled with prostigmine the use of the Levine gastric tube or the Miller-Abbott tube with suction must be instituted. Kaufman<sup>14</sup> in using prostigmine for the control of postoperative atonic intestinal states has found that patients had a greatly reduced incidence of intestinal distention and urinary retention, with more prompt passage of flatus and an increased frequency of spontaneous bowel movements. Prostigmine is definitely contraindicated in intestinal obstruction, either partial or complete.

**Pulmonary Complications**—The majority of these complications have their origin in the retention of mucous secretions in the tracheo-bronchial tree. Atelectasis is the result of mechanical plugging of one or more bronchi by tenacious material which the patient is unable to move. If the patient cannot remove the plug by coughing or change of position collapse of the involved area of lung will result. Heavy preoperative and postoperative medication increases the incidence of atelectasis and bronchopneumonia. An extremely quiet patient with a

depressed cough reflex is an excellent subject especially if he is a heavy smoker, has chronic sinusitis or chronic respiratory infection. Effective coughing, deep breathing and frequent change of position must be encouraged early in the postoperative period. The routine use of large doses of morphine or its prolonged administration will tend to increase the incidence of atelectasis. If atelectasis does occur, the prompt and vigorous aspiration with a tracheal catheter or bronchoscope must be instituted. Pneumonitis, bronchopneumonia or pulmonary suppuration will develop if the atelectatic condition is allowed to persist for any length of time. Kay<sup>13</sup> maintains that heavy premedication which may delay return of movement and of the cough reflex is undesirable as a routine practice. Starr and Gilman<sup>30</sup> have used intercostal nerve block for the relief of upper abdominal wound pain to improve vital capacity and to make coughing easier and more effective.

**Oxygen Therapy.**—Following prolonged surgery the use of oxygen therapy is indicated. Rhode<sup>4</sup> advocates that oxygen therapy be used early to be effective rather than after irreparable damage from anoxia has occurred.

**Postspinal Headache.**—There is inconclusive evidence as to the etiologic factor for postspinal headache. The use of a small gauge spinal needle (22 gauge) and the avoidance of trauma in doing a spinal puncture are important in lowering the incidence of postspinal headache. The treatment consists of keeping the patient flat in bed and the administration of codeine sulfate, grain  $\frac{1}{2}$  (0.032 gm) to grain 1 (0.065 gm), with acetylsalicylic acid, grains 10 (0.65 gm). For the persistent severe headache, the administration of pitressin, concentrated glucose or saline has been proposed. Watson,<sup>35</sup> in discussing the treatment of postspinal anesthetic headache due to aseptic meningitis, has recommended the administration of pitressin or glucose saline which may relieve intracranial pressure by promoting diuresis.

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## COMMENTS ON ANESTHESIA

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IMPROVEMENTS in the practice of anesthesia during the last twenty five years have made possible the more important advances in major surgery. Without adequate, safe anesthesia and proper on-the spot replacement therapy, many prolonged radical operations cannot be carried out successfully. The agents and methods used for producing anesthesia are of little consequence compared to the ability of the anesthetist, except for a few instances in which extremely toxic drugs, such as chloroform, ethyl chloride and cyclopropane are used. There are really no safe anesthetic agents and no safe methods in inexperienced hands. The anesthetic risk to the average patient is almost as great as the surgical risk. It is common practice in many institutions to accept as anesthetists, either poorly trained physicians, or nurses who are not properly supervised. This condition must be corrected before the anesthetic mortality figures are grossly improved.

**The Dangers of Open-Drop Ether Anesthesia**—It is the contention of many surgeons that open-drop ether is the safest of all anesthetic procedures. This contention is false. It immediately invites laxity in the selection of properly trained anesthetists. If one is interested only in getting his patient off the operating table alive, then perhaps open drop ether is the safest of all anesthetic methods. This agent does have a rather wide range of safety between anesthetic concentration in the blood stream and the concentration which will produce complete respiratory rest. However, many patients who survive anesthesia and operation develop postoperative complications which can be directly attributed to their anesthesia. Most patients under open drop ether anesthesia, particularly if the anesthesia is carried deep into the third plane of the third stage, develop definite clinical signs of anoxia. These signs are usually manifested by profuse perspiration, shallow, irregular respiration, cold, clammy skin and a slight cyanosis. This amount of anoxia, superimposed upon the anoxia of operative shock and blood loss, may cause the patient prolonged hospitalization and a stormy period of recovery. Mental changes may develop after a period of weeks if the anoxia has been prolonged.

**Ether with Oxygen and Nitrous Oxide**—It is not the intention to condemn the use of ether for this agent is undoubtedly the safest of all

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inhalation anesthetic agents, provided it is administered properly. Ether, given with a high concentration of oxygen through a modern anesthesia machine, can be given in such a manner as to prevent anoxia from developing during the course of operation and maximum relaxation can be obtained using a minimum amount of the anesthetic agent. There are very few patients requiring operation who cannot be anesthetized safely with ether and oxygen. Cardiac patients requiring surgery tolerate ether anesthesia better than any other agent or method available. Most cardiacs will maintain normal blood pressure, normal pulse rates and will seem to have improved circulation during light ether anesthesia. This is not true of any other agent or method; cyclopropane included.

It is somewhat difficult for most patients to go through an ether-oxygen induction. However, the choking and coughing sensation experienced by these patients can be completely eliminated by starting all anesthetic inductions with nitrous oxide and oxygen. As soon as the patient's reflexes have been diminished by the analgesic effects of nitrous oxide, ether can be added to the mixture gradually, nitrous oxide administration discontinued, and the patient carried into the proper depth of anesthesia without difficulty. If induction is done properly, most patients will not exhibit an excitement stage. All nitrous oxide inductions should be carried out in such a manner as to insure the patient complete oxygenation of his blood throughout his period of anesthesia.

It is the custom of many anesthetists to start nitrous oxide-oxygen and ether anesthesia by using pure nitrous oxide for the first one or two minutes of anesthesia. This is a very dangerous procedure and results in unconsciousness of the patient, not from the anesthetic effects of nitrous oxide, but from suffocation and anoxia. Nitrous oxide should never be given in concentrations which prohibit the simultaneous administration of 20 per cent oxygen. If an anesthetic induction is begun using 80 per cent nitrous oxide and 20 per cent oxygen, the patient will receive sufficient analgesic effect from the nitrous oxide to allow him to breathe ether vapor without irritation to his tracheo-bronchial tree. This concentration assures the patient the same amount of oxygen that he would be breathing were he breathing room air. A mixture of 20 per cent oxygen and 80 per cent nitrous oxide is capable of producing early first plane, third stage anesthesia in most individuals who have been properly premedicated. It is not capable of producing surgical anesthesia except at the expense of oxygen.

In the proper induction of nitrous oxide-oxygen and ether anesthesia, all nitrogen must be removed from the anesthesia machine before the actual administration of the anesthetic is begun. Otherwise a sufficient concentration of nitrous oxide to produce analgesia or light anesthesia cannot be obtained. After all nitrogen has been removed from

the anesthesia apparatus and it has been filled with 80 per cent nitrous oxide and 20 per cent oxygen the mask is placed on the patient's face and he is asked to breathe normally. A high flow of both nitrous oxide and oxygen is maintained for two or three minutes time. It is our practice to run a flow of 4 liters of nitrous oxide and 1 liter of oxygen per minute with the expiratory valve open. This flow is maintained until the nitrogen in the patient's lungs has been diluted and removed from the system. After the patient is breathing the nitrous

metered into the system at a rate of flow sufficient to keep the anesthetic bag filled with gas. This flow will vary from 350 to 500 cc per minute. The amount of ether delivered to the anesthetic machine is now increased gradually until the patient passes into third stage second plane of anesthesia at which time the operation may begin. This induction period consumes from ten to twelve minutes time. If the system is kept completely closed and all carbon dioxide is removed through a soda lime filter most operations can be completed using less than 3 ounces of ether. Prolonged operations lasting as long as five or six hours are frequently carried out using less than 5 ounces of ether.

**Advantages of Endotracheal Administration**—Many surgeons as well as anesthetists have been reluctant to adopt endotracheal methods except in certain selected cases. We believe that almost all general anesthesia should be administered through an endotracheal airway. The possibility of respiratory obstruction is eliminated and relaxation using a minimal amount of ether can be obtained. Very frequently poor relaxation during an operation under general anesthesia is the result of obstruction either in the pharynx or at the site of the vocal cords. Patients who are obstructed use all accessory muscles of respiration, including abdominal muscles in an attempt to overcome the obstruction. In these patients good muscular relaxation cannot be obtained until the airway has been cleared. There are practically no contraindications to the use of an endotracheal catheter provided the anesthetist is capable of doing laryngoscopy. There are no mysteries to laryngoscopy. It can be learned by anyone with a little practice.

**Role of the Anesthetist in Obtaining Good Relaxation**—Surgeons as well as anesthetists are frequently responsible for increased anesthetic morbidity and mortality. The lack of poor relaxation and the lack of knowledge of the cause of poor relaxation both on the part of the surgeon and the anesthetist may result in death on the operating table from an overdose of any inhalation anesthetic agent. Inexperienced anesthetists are usually fearful of the surgeon and will carry out his instructions to the letter without thought of the possible consequence.

If a patient is carried into deep third plane, third stage anesthesia for an abdominal operation, the intercostal muscles become paralyzed. After intercostal paralysis has taken place, the diaphragm attempts to take over the entire function of respiration and in so doing becomes very vigorous in its movements. Instead of the smooth, even movement of normal diaphragmatic action, the diaphragm will develop a forceful piston like action. This force is transmitted to the abdominal viscera, the intestines will start bulging from the wound and the surgeon frequently attributes the condition to light anesthesia. If the surgeon orders the anesthetist to deepen the anesthesia, the condition will become progressively worse until respiration ceases entirely. Unless proper and immediate resuscitative measures are carried out, in other anesthetic death of unknown cause may be recorded in the files of the laboratory department.

The surgeon as well as the anesthetist should be completely aware of the condition of the patient and the depth of anesthesia at all times. If intercostal paralysis does develop and the condition just described exists, deeper anesthesia will not provide additional relaxation. The patient needs only to have the administration of the anesthetic stopped and to be allowed to breathe air or oxygen for a sufficient length of time to desaturate his blood stream partially of its anesthetic content. As soon as the intercostal muscles once more become active and take up their normal function of respiration, the diaphragmatic movements will be less vigorous and abdominal relaxation will be complete.

Phonation during anesthesia usually results in poor abdominal relaxation. The introduction of an endotracheal catheter during phonation will prevent the patient from closing his vocal cords and contracting his abdominal muscles in an attempt to ventilate his lungs.

**Anesthesia for Upper Abdominal Operations**—Most upper abdominal operations should be carried out using gas, oxygen and ether anesthesia by the endotracheal technic. The presence of the endotracheal tube will assure an unobstructed airway, it will allow complete abdominal relaxation with a minimum of anesthetic drug, and it will usually prevent the aspiration of mucus and vomitus into the patient's lungs. In most cases of upper abdominal surgery, gastric content passes up the esophagus into the pharynx. This may occur by gravity drainage or may be due to pressure exerted on the gastrointestinal tract by the surgeon. During surgical anesthesia the cricopharyngeus muscle and the cardiac sphincter are relaxed. If gastric content does pass into the pharynx, it is apt to find its way into the tracheobronchial tree unless an endotracheal catheter is in place. The presence of an endotracheal catheter also allows aspiration of mucus or other foreign material from the tracheobronchial tree at the termination of anesthesia.

We have just stated that most upper abdominal operations should



be carried out under inhalation anesthesia. The one exception is operation for *perforated peptic ulcer*. Most patients with a perforated peptic ulcer are seen by the surgeon and brought to operation before the onset of severe dehydration and shock. These individuals exhibit board like abdomen and require *profound anesthesia in order to assure the surgeon ideal operative conditions*. Most of these ulcers are sealed off at the time they are seen by the surgeon. Everything possible should be done to prevent the breaking of this seal in order to prevent gross contamination of the abdominal cavity. A stormy induction of general anesthesia, with possible nausea and vomiting during induction might prove to be the deciding factor in the eventual outcome of the patient's surgery. Consequently, general inhalation anesthesia is contraindicated in most of these individuals. It is our policy to use spinal anesthesia in all cases of perforated peptic ulcer unless some definite contraindication to the use of this method exists. It is true that some patients become nauseated and vomit during spinal anesthesia but this danger can be completely eliminated by the intermittent administration of sodium pentothal intravenously, in doses just sufficient to put the patient into an analgesic state and depress the vomiting center. This combination of agents and methods will give the surgeon ideal working conditions and allow him to complete the operation in the shortest possible time.

**Anesthesia for Lower Abdominal Surgery**—Most lower abdominal surgery can be done either under spinal or inhalation anesthesia. However, we believe that most major gynecologic operations should be carried out using gas, oxygen and ether by the endotracheal technique. This method will relax the abdominal muscles completely and will eliminate the possibility of nausea and vomiting during the anesthesia. Most women undergoing major pelvic surgery are subject to a great deal of emotional distress. These patients should not be subjected to the rather horrifying experience of having their surgery accomplished while they are awake and aware of everything about them. The Trendelenburg position alone is enough contraindication to the use of spinal anesthesia in most patients.

**Intravenous Anesthesia**—Intravenous sodium pentothal anesthesia has gained wide acceptance throughout the country. Pentothal, if used properly and in selected cases, is a very valuable addition to the armamentarium of the anesthetist. However, many deaths have been reported from the use of this drug, largely because the agent has been used either by inexperienced personnel or in patients who were undergoing surgery which should have been carried out using some other type of anesthesia. Pentothal anesthesia is contraindicated for surgery about the neck or throat, especially in the presence of infection. It should not be used on patients who are being operated in the prone position and it should be used very judiciously in patients suffering from hem

orrhage or extreme debility. The widespread use of this drug for prolonged major surgical operations, even in the hands of those experienced in its use, will result in an increased rate of mortality.

Patients who are to undergo surgery under pentothal sodium anesthesia are prepared preoperatively in the same manner as those who are to have an inhalation anesthetic agent. Food is withheld for at least six hours prior to operation and the patient is mildly sedated. The average adult patient, who is in relatively good physical condition, is given  $1\frac{1}{2}$  grains of pentobarbital sodium approximately two hours before the beginning of the anesthetic. One and one-half hours prior to anesthesia, the patient is given morphine, grain  $\frac{1}{8}$  or  $\frac{1}{6}$ , with  $\frac{1}{150}$  grains of atropine sulfate. Larger doses of atropine will probably not increase the efficiency of the drug and may have the undesirable effect of producing typical toxic symptoms of atropine overdose. The average pentothal induction, as practiced by most anesthetists in the country, is carried out too rapidly. It is the custom of most anesthetists to give an initial dose of 5 or 6 cc. in 2.5 per cent solution of pentothal sodium, then ask the patient to start counting. The patient will frequently count up to twenty-five or thirty at which time an additional 3 or 4 cc. of the anesthetic solution is given. Suddenly the patient drops off into what seems to be a state of anesthesia, respiration usually stops temporarily and the surgeon will proceed with the operation. The patient will usually move and the anesthetist will immediately give another fairly large dose of the drug. The patient may continue to struggle until an overdose of pentothal has been given. At this time a complete cessation of respiration may take place necessitating resuscitative measures.

A safe pentothal induction should be carried out exactly as one would carry out induction using one of the inhalation anesthetic agents. General anesthetic drugs, to be effective, must reach the blood stream and be distributed evenly throughout the tissues of the body in such a concentration as to bring a uniform blood level of the anesthetic drug high enough to maintain surgical anesthesia in a uniform plane. To bring about a uniform blood concentration, it is necessary to inject the intravenous drugs rather slowly. Should a sudden overdose be given, the concentration in the arterial blood passing through the brain may become high enough to cause respiratory arrest. A safe and satisfactory method of pentothal induction can be carried out in the following manner. Approximately 2 cc. of 2.5 per cent concentration of pentothal sodium is injected into any easily accessible vein. The patient may either be engaged in conversation or asked to count. No further amount of the drug is given until at least one minute has passed. If the patient is still obviously awake, at the end of one minute, approximately one or two cubic centimeters of the anesthetic solution is given. This slow administration is continued until the patient

drops off into a quiet sleep. Usually a very short period of respiratory arrest will be noted at the time the patient becomes unconscious. After normal respiration is resumed, small amounts of the drug can be given intermittently until the eyeball movements have disappeared and the eyes become centered. Loss of eyeball activity and centering of the pupils represents second plane, third stage anesthesia in most patients. This method of induction will usually require eight or ten minutes time. The surgeon should never proceed with the operation until the patient is in third stage, second plane anesthesia. If slow inductions are carried out routinely, dangerous respiratory arrest will almost never occur, the dangers of sudden overdose will be eliminated and the total amount of the drug required for any given operation will be greatly reduced.

**Cyclopropane—a Dangerous Anesthetic Agent**—Cyclopropane has been widely used during the last ten years and many anesthetists have insisted upon its use in almost all conditions. Cyclopropane is one of the most dangerous anesthetic agents in use today. Many deaths occur on the operating table, especially during the induction phase of anesthesia. It has often been said that the use of this drug should be restricted to those who are competent in its administration. The anesthetic death rate during the administration of cyclopropane anesthesia is high, even in the hands of those who are said to be competent. Death is sudden and it is thought to be due to ventricular fibrillation. It occurs without warning and present methods of resuscitation usually will not save the patient. If the administration of cyclopropane is in itself a condition of the patient's

pulse rate. Many patients undergoing prolonged operations may seem to be in very good condition throughout the operation. The anesthetist may be inclined to delay proper replacement therapy because of lack of indications such as elevation of pulse rate and fall in blood pressure. Soon after the administration of the anesthetic is discontinued, the patient may show a marked fall in blood pressure and elevation of pulse rate and go into a condition of cyclopropane shock. Once this condition develops, it is extremely difficult to combat. Patients may remain in a condition of cyclopropane shock for many hours following administration of the gas in spite of blood and plasma transfusions and the administration of stimulants. Many patients develop postoperative psychosis following the administration of cyclopropane. This condition may be the result of the toxic effect of the drug on the higher centers or it may be the result of anoxia. Once postoperative psychosis develops it is often necessary to restrain the patient in bed and to quiet him with narcotics and sedatives for many hours. Anesthetists who deny that such things happen following the administration of cyclopropane simply have not followed their

patients to the postoperative wards. It is often said that cyclopropane is indicated because of the high concentration of oxygen that can be administered with this gas. It is true that high concentrations of oxygen can be administered with cyclopropane but the percentage of oxygen is not as high as that which can be administered with ether. Cyclopropane, to be effective, must be given in concentrations of 25 to 35 per cent in the inspired mixture. Ether, given with oxygen in the closed anesthesia system, is breathed at a concentration of about 4.5 to 5 per cent, for maintenance of anesthesia, thus allowing the patient to breathe approximately 95 per cent oxygen at all times.

**Anesthesia for Thoracic Surgery**—Anesthesia for thoracic surgery requires greater skill and vigilance than is required of an anesthetist in any other field. Nitrous oxide-oxygen induction with oxygen ether maintenance by the endotracheal method—is the safest of all anesthetics for major thoracic operations such as lobectomy, pneumonectomy, removal of mediastinal tumors, and removal of foreign bodies from the lung. Controlled respiration is not often necessary in these individuals and most patients seem to get along better if controlled respiration is not carried out. If the patient is suffering from suppurative disease of the lung, extreme vigilance must be maintained at all times to prevent respiratory obstruction from developing. All patients suffering from suppurative disease of the lungs who are to be anesthetized should be given the benefit of postural drainage immediately before the administration of the anesthetic is begun. The nitrous oxide, oxygen, ether sequence is carried out as previously described. An endotracheal tube with an inflated cuff may be used to seal the airway or a tight mask may be fitted over the patient's face so that positive pressure may be used when indicated. The patient is kept in early second plane of third stage anesthesia. As soon as the surgeon is ready to enter the thoracic cage, positive pressure of approximately 6 to 8 cm. of water should be maintained in the anesthesia bag to prevent the sudden collapse of the lungs after the pleura has been opened. If sudden collapse is allowed to take place, the patient will develop a condition comparable to a large sudden traumatic wound: the mediastinum shifts and paradoxical respiration develops. If the condition is not corrected at once, the patient becomes anoxic from lack of proper lung ventilation and the flutter of the mediastinum may seriously hamper circulation of blood in the thorax. If pressure is maintained for one or two minutes after the chest is opened and gradual decompression of the lungs is carried out, most mediastinums will stabilize and the patient will be able to breathe effortlessly and with sufficient volume to insure complete oxygenation of the blood. If the patient does develop paradoxical respiration, a sufficient amount of pressure should be exerted through the anesthesia apparatus to stabilize the mediastinum and to insure adequate lung ventilation.

The patient must be draped in such a manner that the anesthetist can see into the open chest at all times. He can gain more information regarding the patient's condition by watching the diaphragm than he can in any other manner. Diaphragmatic movements under ordinary circumstances are smooth and regular in character. If a diaphragm starts moving like a piston, one of three conditions has developed. If the patient is suffering from suppurative disease of the lungs, a large quantity of pus may have gravitated from the diseased lobe into the bronchi of the opposite lung causing obstruction. The diaphragm will work vigorously in an attempt to overcome this obstruction. If this condition has developed tracheobronchial aspiration must be done immediately. If the obstruction cannot be removed by means of passing a catheter through the endotracheal tube, bronchial aspiration by direct vision should be carried out without delay. If the sudden diaphragmatic movement has not been caused by obstruction, it may be the result of mediastinal flutter. In this event the condition may be corrected by adding 6 to 7 cm. of water pressure through the anesthetic machine. Third stage, fourth plane anesthesia with intercostal paralysis may also cause increased diaphragmatic movement. This condition will be recognized immediately if the anesthetist has been aware of the stage of anesthesia from the beginning. Should this condition develop lightening of the anesthesia will correct it within a few minutes' time.

Occasionally a patient is seen who must be carried on a slight amount of positive pressure throughout operation although this condition is rare. If a patient is breathing normally without positive pressure, he may be spared the increased exertion necessary when positive pressure is maintained. Prolonged positive pressure adds greatly to the fatigue of the patient. During lobectomy the remaining lobes which have been deflated for surgery because of lack of positive pressure should be re-expanded every thirty or forty five minutes throughout operation. The anesthetist must be prepared to do tracheobronchial aspiration frequently and he must never wait until signs of anoxia develop before aspirations are carried out. Elevated blood pressure and increased pulse rate are late signs of anoxia. These signs need not develop if the anesthetist watches the patient's diaphragmatic movements and the movements of the anesthetic bag closely at all times and is prepared to do immediate tracheobronchial aspiration when necessary. Most patients who die on the operating table during thoracic surgery die because of obstruction and anoxia and not because of vagovagal reflexes. We have never seen a condition develop during a thoracic surgical operation which will fit the physiological description of vagovagal reflexes.

Spinal anesthesia is contraindicated in all thoracic operations regardless of the ability of the anesthetist. Patients undergoing thoracic operations under spinal anesthesia are in a state of anoxia due to de-

creased circulation throughout their operation. It is very difficult to maintain positive pressure in the lungs of individuals while they are awake. It is impossible to do repeated tracheobronchial aspirations as is required in all cases of suppurative disease of the lung. There is no justification for ever using this method of anesthesia for major thoracic surgical procedures. We believe that ether and oxygen is safer than any other method for all major thoracic operations, including those on patients with tuberculosis.

**Anesthesia for Operations on Heart and Pericardium**—Patients undergoing operation on the heart and pericardium require very special attention on the part of the anesthetist. They should be handled the same as patients undergoing any other major thoracic surgical operation. Occasionally a heart will start to fibrillate due to constant trauma of the myocardium. This fibrillation can usually be controlled by allowing the heart to swim for a few minutes in 10 or 15 cc. of a 5 per cent solution of procaine in saline. If local application of procaine fails to control fibrillation, 5 cc. of 1 per cent procaine solution injected slowly intravenously will usually control the condition.

**Notes on Spinal Anesthesia.**—Spinal anesthesia may be used for most operations below the diaphragm provided the patient is a good operative risk and a safe dose of the anesthetic agent is used. Most operations lasting less than one hour can be done satisfactorily using procaine as the anesthetic agent. Operations of longer duration under spinal anesthesia must be done either by using a continuous spinal technic or by using a drug which has a more prolonged action than procaine. A combination of pontocaine and procaine for spinal anesthesia in operations lasting up to two and one-half hours is satisfactory. Pontocaine should never be injected in quantities greater than 14 mg. A concentration of pontocaine in the injection fluid should not exceed 0.5 per cent. We usually use pontocaine procaine mixtures in a 5:1 ratio, that is, 5 mg. of procaine crystals for every 1 mg. of pontocaine used. This combination insures a very rapid onset of anesthesia and the solution injected in approximately 0.4 per cent solution of pontocaine is slightly hyperbaric, thus allowing the anesthetist to exercise some control over the height of anesthesia by positioning the patient properly on the table.

We are opposed to the use of a combination of pontocaine and glucose or dextrose. A glucose and pontocaine solution is much heavier than spinal fluid. A slight degree of Trendelenburg within the first twenty minutes following administration of the anesthetic agents may result in anesthesia to the clavicles. A slight lordosis of the patient's spine may be great enough to result in extremely high spinal anesthesia if glucose has been added to the pontocaine solution. When a slightly hyperbaric solution is injected into the subarachnoid space and the patient placed on his back, the solution slowly gravitates cephalad.

and, as it gravitates, rapid diffusion takes place, allowing the anesthetic drug to be evenly distributed along the cord to a point approximately opposite the fifth dorsal vertebra, downward. If an extremely hyperbaric solution such as pontocaine and glucose is injected into the subarachnoid space and the patient placed immediately on his back the injected fluid will gravitate rapidly to a point approximately opposite the fifth dorsal vertebra. Maximum diffusion takes place from this point, the diffused drug extends cephalad and often results in extremely high anesthesia with occasional respiratory paralysis.

It is a well known fact that high concentrations of dextrose or glucose solutions are very irritating to unspecialized subcutaneous tissues. On this basis alone, we question the advisability of injecting glucose or dextrose into the subarachnoid space to come into direct contact with the highly specialized tissues of the spinal cord.

**Regional Anesthesia**—Regional anesthesia has come to play a large part in modern anesthesia technic. Most major surgical operations outside of the chest can be carried out using regional methods provided the anesthetist and surgeon are extremely careful and painstaking in their technic and provided complete cooperation can be obtained from a well premedicated patient. Procaine has many uses other than for nerve blocks preceding surgical operations. Simple infiltration for pleurisy is one of the most gratifying of all procedures, especially to the patient. Most patients suffering from severe pain in the chest either from pleurisy or pulmonary infarction, can be relieved completely and within five or ten minutes, by the subcutaneous infiltration of 1 per cent procaine over the painful area. It is neither necessary nor desirable to attempt intercostal nerve block on these individuals. Frequently the pain will not recur. If it should recur, there is no contraindication to carrying out the procedure as often as may be required.

Sympathetic nerve block is of great value, both from the diagnostic and therapeutic viewpoints. Many cases of thrombophlebitis, trench foot, and other vascular conditions can be improved by doing repeated blocks of the sympathetic nervous system supplying the particular area of the body.

# BRONCHOSCOPY AND THE SURGEON

LT COLONEL BRIAN BLADES AND MAJOR L H MOUSEL

MEDICAL CORPS ARMY OF THE UNITED STATES

THE bronchoscope was introduced by Killian in 1897. It is lamentable that during a period of more than forty years this valuable instrument has not been utilized to its full benefits. One factor which kept the bronchoscope out of general use was its invention and control by otolaryngologists who in many instances have little interest in the instrument except for the removal of foreign bodies. Another has been the general impression that the technic of bronchoscopy is difficult to learn. Neither of these fallacies is the direct fault of the nose and throat specialists. And all who are interested in bronchoscopy will gratefully acknowledge the pioneer work undertaken by this group. The time has arrived, however, when the bronchoscope is being employed by others—by anesthetists, surgeons and in some cases internists particularly interested in thoracic disease.

In the modern surgical clinic the responsibility of emergency bronchoscopy in the operating room will logically fall on the members of the department of anesthesia. In the field of thoracic surgery the surgeon or one of his associates should be capable of performing bronchoscopy, but even in this specialized field it is of tremendous advantage to have available anesthetists capable of carrying out bronchoscopic aspirations.

The purpose of this clinic is to discuss the role of bronchoscopy in the preoperative and postoperative management of various surgical diseases and to reemphasize the value of the bronchoscope in the treatment of pulmonary complications following any operation.

## PREOPERATIVE BRONCHOSCOPY

Preoperative bronchoscopy is of greatest value in the field of thoracic surgery. In this specialty bronchoscopy has about the same relationship to operations on the chest as cystoscopy in genito urinary surgery. In this connection it should be noted that only in recent years have many thoracic surgeons performed bronchoscopies. The absurdity of a thoracic surgeon referring patients for bronchoscopic examinations can be realized when one imagines the urologist's reaction to the suggestion that cystoscopy be performed by a specialist dependent upon the urologist to tell him when to use the instrument.

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Preoperative bronchoscopy may be divided into two phases—(1) diagnostic, and (2) therapeutic

1 **Diagnostic Bronchoscopy**—Diagnostic bronchoscopy is employed to establish the presence of endobronchial tumors foreign bodies ulcerations or stenosis of the bronchi. Biopsy material or cultures of secretions obtained through the bronchoscope may establish a positive diagnosis when disease is present. In suppurative diseases of the lung visualization of the source of pus will be an aid in the precise localization of the lesion. The omission of examination of the tracheobronchial tree in candidates for major thoracic surgery is rarely excusable.

2 **Therapeutic Bronchoscopy**—The preoperative therapeutic use of the bronchoscope is largely confined to cases of pulmonary suppuration in which operative interference is contemplated. For example in patients with bronchiectasis or pulmonary abscesses bronchoscopic aspirations will often be followed by diminishment of the amount of sputum and improvement in general condition. In a few cases of pulmonary abscesses bronchoscopic aspiration may result in evacuation of pus and healing of the abscess cavity. This is particularly true if bronchoscopy is performed before the lesions become chronic. It should be emphasized however that it is impossible to guarantee a cure of suppurative disease of the lung by this method and that it is safer to plan to employ bronchoscopy as an adjunct to thoracic surgery rather than to expect a large percentage of permanent cures.

More than 50 per cent of endobronchial tumors can be visualized through the bronchoscope. Failure to obtain tissue for a positive diagnosis however does not justify postponement of exploratory operations if pulmonary neoplasms are suspected. It is also worth emphasizing that the possibilities of successful treatment of endobronchial tumors by removal through the bronchoscope are limited. Early optimistic statements on the cure of pulmonary and esophageal cancer by peroral endoscopy have not been substantiated by the hard facts of experience.

It has been recommended by some surgeons<sup>1</sup> that suction be applied through the bronchoscope immediately before intrathoracic operations for lung abscess or bronchiectasis are undertaken in order to remove as much of the retained pus as possible. A fair trial of this method over a period of years has convinced us that instrumentation of the tracheobronchial tree immediately preceding induction of anesthesia is not desirable. There is considerable coughing after the withdrawal of the bronchoscope bleeding may be provoked and difficulties during the operation may be increased. Better results are usually obtained if bronchoscopy is performed two or three days before the operation and careful postural drainage is employed immediately before the anesthetic is given.

## EMERGENCY BRONCHOSCOPY ON THE OPERATING TABLE

Even in cases of severe pulmonary suppuration the skillful administration of an anesthetic agent through an intratracheal catheter usually eliminates the necessity of performing an emergency bronchoscopy during the course of an operation. Occasionally, however, the entire tracheobronchial tree will be flooded with pus, blood or vomitus. When this distressing complication arises, the patient's life will depend upon immediate clearing of the airways. It is apparent, therefore, that every operating room should have available personnel and equipment to carry out this procedure. It is admitted that this complication rarely arises except in operations upon the chest. There are, however, occasional instances in all types of surgery where bronchoscopy will be life saving. Lack of facilities to meet this dreadful emergency is as disgraceful as failure to provide measures for transfusion of blood in cases of hemorrhage.

The most common causes of death in the operating room, namely, hemorrhage and suffocation, can usually be prevented. Suffocation is often easier to control than severe hemorrhage.



Fig 434—A Roentgenogram of the chest showing extensive infiltration and atelectasis of the right lung B, Appearance of the lung twenty four hours after the emergency bronchoscopic aspiration

CASE I—A 22 year old primipara was delivered of a normal living fetus under nitrous oxide, oxygen and ether anesthesia. Within a short time following delivery, the patient vomited large quantities of gastric content and some of this material was aspirated into the trachea. She became cyanotic and the pulse and respiratory rates increased. Examination of the chest revealed many bubbling rhonchi and somewhat decreased breath sounds on the right. There was a definite lag to the excursion of the right chest. The trachea was aspirated as thoroughly

as possible by means of a catheter soon after the vomitus had been drawn into the lungs. Cyanosis persisted and the chest findings were unchanged in spite of the tracheal aspiration (Figure 434 A demonstrates the lesion in the right lung). One half hour after the first x ray was taken the patient was bronchoscoped and a large amount of gastric contents was found in the right stem bronchus. A considerable quantity could be seen coming from the bronchi of the upper middle and lower lobes. The bronchoscope was left in place for several minutes so that the patient would continue to cough. All foreign material visualized was removed by aspiration. Immediately following bronchoscopy the patient's cyanosis disappeared and the pulse and respiratory rates returned to normal. Convalescence was uneventful and a roentgenogram on the following day showed satisfactory clearing of the right lung (Fig 434 B).

### POSTOPERATIVE BRONCHOSCOPY

**Routine Postoperative Bronchoscopy**—Aspiration of the bronchial tree through the bronchoscope immediately after operation is indicated in the majority of major thoracic procedures. This is particularly true when partial or complete lung resection has been performed. The needs for routine bronchoscopic aspiration after operations in other parts of the body are not so frequent. There are occasions however particularly in patients of the older age group where bronchitis or other chronic pulmonary lesions may make bronchoscopy a valuable adjunct in the postoperative care. Frequently, emergency operations must be performed without adequate preoperative preparation of the patient. This may occur in obstetrical cases, acute diseases of the abdomen and operations for various injuries. Under these circumstances vomiting is common. If a general anesthetic has been necessary and vomiting has occurred the precaution of bronchoscopic aspiration before the patient regains consciousness will guarantee splendid dividends in postoperative results.

If there is any doubt whatever concerning the advisability of removing accumulated secretions under these circumstances the procedure should be done before the patient reacts from the anesthesia. It can be stated categorically that bronchoscopy performed in the operating room while the patient is still under the influence of general anesthesia carries practically no risk. Conversely, if one fails to remove mucus, pus or blood from the tracheobronchial tree, the chances of postoperative atelectasis or other complications are tremendously increased.

**Treatment of Postoperative Atelectasis**—Many cases of postoperative atelectasis can be relieved by forcing the patient to cough and turning the affected side of the chest up. If this fails some have recommended the use of carbon dioxide inhalations. If these measures fail aspiration of the tracheobronchial tree can be accomplished with a rubber catheter as recommended by Haight. It has been our impression however that if simple measures do not immediately relieve atelectasis bronchoscopic aspiration is desirable. This statement is based upon two ob-

servations (1) the indisputable fact that when the tracheobronchial tree is examined by direct vision through the bronchoscope, a more satisfactory and complete removal of secretions can be accomplished, (2) that the actual discomfort from a properly performed bronchoscopic aspiration is no more than the distress accompanying blind catheter aspirations. This second point has been established in our clinic by trying both methods on twelve patients, all of whom declared that bronchoscopy gave them more relief and had caused no more discomfort than the use of the catheter. This apparently is true because when the bronchoscope is employed the patient has a relatively free airway, but when the catheter is introduced there is not sufficient room through its lumen for an airway, nor is there space between the catheter and the tracheal walls. This produces a sense of suffocation, violent straining and coughing. It is our opinion that some of the benefits of the catheter method are the result of the violent breathing and paroxysms of coughing which loosen secretions and not from actual suction through the catheter itself.

It is of the utmost importance that the complication of pulmonary atelectasis be followed carefully by roentgenographic examinations, and in patients in whom there is reason to believe that the disease and type of operation might result in atelectasis, routine postoperative roentgenograms should be obtained. Frequently, cases of atelectasis can be treated and cured in an early stage. If one waits until there are fully developed clinical manifestations of atelectasis, the condition may be more difficult to relieve and not infrequently several aspirations of the tracheobronchial tree are necessary before the affected lobe or lobes will remain permanently aerated.

Physical signs cannot be relied upon to determine the amount of aeration of a pulmonary lobe or lobes. By the time changes in percussion, auscultation and other physical signs are apparent, usually an entire lobe is affected. This may not be serious in a patient in good general condition, but in the borderline case extensive atelectasis may be extremely dangerous. It is also important to emphasize the inadequacy of physical examinations in determining the condition of the lung after atelectasis has been relieved. Residual rales may persist for many days and it is only by repeated roentgenographic studies that the true condition of the lung may be established.

CASE II—A 20 year old white male was admitted to the hospital for treatment of chronic productive cough, wheezing and occasional hemoptysis. The illness was of approximately one year's duration. The onset was characterized by an acute respiratory infection and was followed by a persistent cough productive of foul sputum and some bleeding.

The past history and family history were not helpful in determining the diagnosis.

Bronchography revealed saccular bronchiectasis of the left lower lobe and lingula of the left upper lobe. Preoperative examination with the bronchoscope

revealed no endobronchial obstruction. Pus could be seen coming from the left lower and left upper lobe bronchi.

The left lower lobe and lingula of the left upper lobe were removed on July 11, 1945. A roentgenogram taken in the operating room revealed excellent expansion of the remaining left upper lobe. For the first two days after the operation the patient's course was excellent. On the third postoperative day there was elevation of temperature to 101° F and the fingernails were slightly cyanotic. A roentgenogram of the chest revealed complete atelectasis of the left upper lobe (Fig 435, A). Bronchoscopy was performed immediately and a mucous plug and several cubic centimeters of thick, tenacious material were removed from the left upper lobe orifice. On the following day the left upper lobe was expanded satisfactorily (Fig 435 B).



Fig 435—A, Roentgenogram of the chest showing atelectasis of the left upper lobe which followed an operation for removal of the left lower lobe and lingula of the left upper lobe. B, Roentgenogram demonstrating the aerated left upper lobe following bronchoscopy for atelectasis. The catheter which had been placed in the chest at the time of the operation had been removed.

*Comment*—This is not an uncommon complication following lobectomy. When the combination of left lower lobe lobectomy and lingulectomy is carried out, the surgeon should be particularly vigilant in watching for atelectasis of the remaining left upper lobe, since the ligation of the lingula bronchus may cause edema of the left upper lobe bronchus. In some cases it is necessary to perform several postoperative bronchoscopies to keep the left upper lobe expanded.

*When Is Postoperative Bronchoscopy Necessary?*—Postoperative bronchoscopy is recommended without hesitation in all patients who have undergone operations upon the lung. Not only is bronchoscopy indicated in this group of patients, but one should make absolutely certain that pulmonary expansion has been accomplished before the patient is allowed to react from the anesthesia. A routine suggested by Mousel<sup>3</sup> has been found ideal in the management of patients who have undergone major intrathoracic operations: postoperative bronchoscopy

is performed as soon as the operation is completed. After the bronchoscopy, a roentgenogram of the chest is obtained while the patient is still on the operating table and before he regains consciousness. If there is pneumothorax or atelectasis, it will be detected. In a great majority of cases the condition of the lungs will be found satisfactory. In a few instances, however, the patient's life may depend upon this precaution.

**CASE III**—A 24 year old white male was admitted to the hospital because for the past seven months he had had bouts of fever and severe cough, productive of purulent sputum. The onset of the illness was characterized by hemoptysis and he continued to cough up small amounts of blood. The symptoms persisted for seven months. There was weight loss and the tips of the fingers and toes became clubbed.

The past history and family history were not helpful in establishing the nature of the lesion in the lung.

Roentgenograms of the chest revealed a lesion which seemed to be situated in the left upper lobe and appeared to involve the dorsal division of the left lower lobe.

Upon bronchoscopic examination, pus could be seen coming from the left main bronchus and from the lower and upper lobe bronchi. There was no evidence of endobronchial tumor.

It was impossible to be certain before the operation whether the lesion was a lung abscess or a bronchiogenic tumor. On June 22, 1945, the left chest was explored. Practically the entire left upper lobe was indurated. The dorsal division of the lower lobe and the upper lobe were fused with tough adhesions and a hard mass was palpable in the dorsal division of the lower lobe. A total pneumonectomy was performed. Examination of the specimen revealed two large lung abscesses, one in the upper lobe, the other in the dorsal division of the lower lobe (Fig 436 A).

Immediately after the operation the patient's condition seemed excellent. The pulse was 110, blood pressure 118/80, respirations 26, the color good. As soon as the operation was completed, the bronchoscope was inserted and a rather large amount of bloody pus was removed from the right lung. This material had accumulated during the course of the operation despite repeated catheter aspirations. A roentgenogram of the chest was made immediately after bronchoscopy (Fig 436 B).

It was apparent that a large portion of the right lung was atelectatic. A second bronchoscopic aspiration of the right lung was performed (Figure 436 C shows the appearance of the right lung after the second bronchoscopy). The right lung remained expanded and the patient made an uneventful recovery (Figure 436 D, shows the lung on the first postoperative day).

**Comment**—There can be little doubt that this patient might have died within a few hours after the operation if the bronchi of the remaining right lung had not been cleared of accumulated blood and pus. This case also demonstrates that the clinical appearance of a patient cannot be depended upon to estimate the condition of the lungs. During the course of the operation a mixture of oxygen ether (approximately 95 per cent oxygen) had been given. It is worth emphasizing that following an anesthetic for any operation in which the pa-



Fig 436—*A* Photograph of left lung showing an abscess in the upper lobe and an abscess in the dorsal division of the lower lobe *B* Roentgenogram made on the operating table immediately after a left total pneumonectomy. The left lung has been removed and almost the entire right lung is atelectatic. *C* This roentgenogram was made about fifteen minutes after the one shown in *B*. Most of the right lung aerated satisfactorily after the second bronchoscopy. *D* A roentgenogram of the chest showing the condition of the right lung on the first postoperative day. The patient made an uneventful recovery and left the hospital in six weeks.

tient has been given a high concentration of oxygen for some time the excellent color of the patient for a short time after the operation is terminated may be misleading.

CASE IV—A 23 year old soldier was admitted to the Thoracic Surgery Section for the treatment of chronic hemothorax. The patient was wounded on February 15, 1945, while in combat in the Philippines. Extensive laceration of the lung resulted in a massive hemothorax. The blood clotted and could not be evacuated by needle aspiration. Accordingly, a decortication operation was performed for



Fig 437—*A*, Roentgenogram of the chest showing the appearance of a large clotted hemothorax in the right pleura. *B*, Roentgenogram taken on the operating table before the patient regained consciousness. It is apparent that there is pneumothorax and unsatisfactory expansion of the pulmonary tissue. *C*, The appearance of the lung after the bronchoscopic aspiration and connection of the intercostal catheters to water seal drainage bottles.

chronic hemothorax on April 27, 1945. (Figure 437, *A* shows the appearance of the chest when the patient was admitted. Figure 437, *B*, reveals the condition of the lungs immediately after closure of the chest.) It is apparent that the patient had a tension pneumothorax and considerable atelectasis. The tension pneumothorax was the result of air leaking into the pleura after the performance of the decortication operation. In this case the line of cleavage between the scar tissue



over the lung was not well developed and the lung was injured during the removal of the scar tissue (Figure 437 C, shows the lung fifteen minutes later after bronchoscopy and removal of air through the intercostal catheters)

*Comment*—A convenient way to decompress tension pneumothorax in this type of case is to perform bronchoscopy with the drainage catheters in the pleura connected to water seal drainage systems. The violent respirations associated with the bronchoscopic examination appear to force out the pneumothorax air and leave the intrapleural pressure at a desirable negative level. This can be accomplished before the patient recovers consciousness.

The decision to perform a bronchoscopy on a seriously ill patient may be difficult to make. Probably the safest rule to follow is that if there is any question concerning the necessity of removal of material from the tracheobronchial tree, a bronchoscopy should be recommended without hesitation. Procrastination in the management of a patient who is drowning in his own secretions frequently leads to death.

In a series of 201 postoperative bronchoscopies performed at the Walter Reed General Hospital in the past year, there have been no deaths or ill effects from the operation. The few minutes of discomfort experienced by the patient are amply rewarded by improvement in respiratory exchange and general comfort. The more distressing the respiratory difficulties before aspiration of the tracheobronchial tree the more relief is afforded the patient by the procedure. To omit or delay bronchoscopic examination on the supposition that the patient's condition is too serious to withstand it usually indicates a complete lack of knowledge of the disease and of the technic of bronchoscopy.

#### METHODS FOR ASPIRATION OF THE TRACHEOBRONCHIAL TREE

The two most effectual methods of removing secretions from the tracheobronchial tree are (1) direct visualization and aspiration of the secretions through the bronchoscope, (2) catheter aspiration. With either technic a certain amount of experience is necessary. It should be emphasized, however, that neither method is particularly difficult to master.

When the patient is completely relaxed from a general anesthetic, the introduction of the bronchoscope is relatively easy. In the conscious patient the exposure of the vocal cords and the insertion of the instrument may be more difficult, but with proper application of topical anesthesia the operation should not cause pain. In the case of emergency aspiration of the tracheobronchial tree, it is sometimes advisable to omit anesthesia. In fact, the use of local anesthesia in these patients may be dangerous, firstly, because the cough and swallowing reflexes may be crippled and secondly, because the delay necessary to

apply the topical anesthesia may be hazardous. It cannot be emphasized too strongly that there should be no hesitation whatever to introduce a bronchoscope or catheter without anesthesia if the patient's respirations are dangerously impaired by retained secretions in the trachea or bronchi.

**Technic for Bronchoscopy**—Bronchoscopy, for the purpose of tracheo-bronchial aspiration, is not a difficult procedure and can be learned quite readily if a simple technic is adopted. Patients who are to undergo bronchoscopic aspiration will usually be somewhat frightened unless the reasons for doing bronchoscopy are given and unless they are warned of all sensations to be expected and assured that there is no danger in the procedure. The fears that many patients have of undergoing bronchoscopic aspiration under topical anesthesia can usually be controlled by the intravenous administration of a small amount of morphine sulfate. One eighth to  $\frac{1}{6}$  grain of morphine sulfate given intravenously, immediately prior to the preparation of the patient, will usually dull his reflex irritability and somewhat allay his fears.

It is necessary in most instances to anesthetize the throat by means of a topical anesthetic agent before bronchoscopic aspiration can be accomplished. Cocaine is probably the most suitable drug for this purpose. The well known toxicity of cocaine makes it necessary to exercise caution in the amount of the drug used in any one individual. It is probably safer to use small quantities of 20 per cent solution of cocaine for topical application in the throat than it is to use larger quantities of a lesser concentration. If cotton pledgets are dipped in 20 per cent solution of cocaine and compressed dry between the fingers before introduction into the piriform fossa, satisfactory anesthesia can be produced with little danger of drug reaction. If soaking wet sponges are used for this purpose or if large amounts of cocaine solution are sprayed into the throat, the patient will most certainly swallow large quantities of the drug. Cocaine is very rapidly absorbed in the gastrointestinal tract, and if the patient is allowed to swallow any amount of the solution, serious or fatal drug reaction may result.

After the throat has been prepared by the introduction of 20 per cent cocaine solution on cotton sponges, directly into the piriform fossa, the patient is moved to the end of the table so that his head can be freely held and controlled by an assistant. The laryngoscope is now passed into the pharynx and advanced slowly along the base of the tongue. During this maneuver, the bronchoscopist should keep the attention of the patient by explaining to him the sensations which he may expect, such as pressure on the upper teeth, pressure on the base of the tongue, and a feeling of not being able to get enough air into his lungs. Assurance that he will have an adequate amount of air to breathe at all times will usually cause the patient to become quiet and cooperative. After the epiglottis has been visualized and lifted with

the tip of the laryngoscope the bronchoscope is passed gently between the vocal cords and into the trachea. The laryngoscope is now carefully removed. After the bronchoscope has been passed into the trachea the patient will usually cough violently for a few seconds making it necessary for a nurse or assistant to hold his shoulders firmly on the table. The bronchoscope is now gently advanced into the trachea until the carina has been visualized. It is then advanced into first one and then the other main bronchus. Each lobe bronchus is visualized and all foreign material is removed with an aspirating tip. The entire procedure of tracheobronchial aspiration will usually not require more than two minutes time.

**Tracheobronchial Aspiration by Means of a Soft Rubber Catheter**—Occasionally it becomes necessary to aspirate the tracheobronchial tree without the aid of a bronchoscope. This procedure can usually be carried out quite easily if one is able to gain the confidence of the patient and obtain his complete cooperation. A few drops of 5 per cent cocaine solution placed in one nostril will make the passage of a catheter less disturbing to the patient. After the nose has been anesthetized the patient is placed in the Fowler position and his head is supported on a large pillow. The catheter is passed gently through the nostril and into the pharynx at which time the patient will usually cough. The catheter is now advanced carefully until it passes into the trachea. If the patient develops a violent coughing spell one can be certain that the catheter has passed between the vocal cords and can now be advanced until the material to be removed from the tracheobronchial tree is encountered. The catheter should be moved about in the trachea for a few seconds time in order to pick up as much of the foreign material as possible. After a few seconds manipulation, all movement of the catheter should be stopped momentarily so that the patient will discontinue his coughing and take a few deep breaths before manipulation is once more resumed. It is often necessary to turn the patient from side to side in order to be relatively sure that the catheter has entered both right and left main bronchi.

#### SUMMARY

Recently developments in all fields of surgery, and particularly in thoracic surgery have resulted in the general use of the bronchoscope in surgical clinics. This instrument will prove of great value as an adjunct in the postoperative management of all surgical cases in which pulmonary complications are encountered. The old idea that bronchoscopy is a dangerous procedure and that the technic is difficult to master must be corrected before the full advantage of bronchoscopic aspiration for postoperative pulmonary complications can be enjoyed. It is apparent that every modern surgical clinic must have available

trained personnel and adequate equipment to perform bronchoscopic aspirations under emergency conditions

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# THE PROTEIN REQUIREMENTS OF SURGICAL PATIENTS DURING THE POSTOPERATIVE PERIOD

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It is well known that patients generally lose weight after undergoing a major surgical operation. The extent of this weight loss is evident in Table 1, which presents an analysis according to the type of operation of the loss of weight sustained by a consecutive series of 385 patients admitted to one surgical ward of a large general hospital. In the ordinary case it is perhaps of no great significance that the patient loses five or ten pounds. It is, however, common experience that several weeks are required to regain this weight and that well

TABLE 1—WEIGHT LOSS AFTER OPERATION

	No of Cases	Average Hospital Stay	Average Weight Lost
		days	lbs
Appendectomies	23	9.9	6.4
Herniorrhaphies	27	13.0	5.2
Cholecystectomies	10	19.8	9"
Gastric and Bowel	31	19.8	7.6
Other Abdominal	17	15.4	12.4
Chest	10	19.7	4.4
Neurosurgical	85	13.7	3.2
Miscellaneous	101	10.1	3.2
Total and Average	304	15.2	6.5
Study—no operation	81	7.5	0.25

being seldom returns until a substantial fraction of the lost weight is recovered. Moreover, in less fortunate patients in whom recovery is delayed because of the seriousness of the illness or because of the development of unforeseen or unavoidable complications this loss in weight may become a very serious matter as it is usually accompanied by a more or less severe form of hypoproteinemia.

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## EFFECTS OF HYPOPROTEINEMIA

The unfortunate effects of hypoproteinemia are well known. It has been demonstrated experimentally,<sup>1,2</sup> and to some extent clinically, that hypoproteinemia is one of the important factors contributing to wound disruption.<sup>3</sup> It has also been shown both experimentally and clinically that hypoproteinemia has a profound influence on gastric emptying and gastrointestinal motility.<sup>4,5</sup> Following gastrectomy and gastroenterostomy the edema associated with hypoproteinemia may be an important and decisive factor in preventing normal function of the stoma. There is some evidence that hypoproteinemia interferes with the formation of callus following fractures.<sup>6</sup>



Fig. 438—Bedsores in protein-deficient patient with transverse myelitis

Furthermore, there is the evidence that many previously resistant bedsores, including some of the so-called trophic ulcers encountered in neurologic wards, may be induced to heal by augmenting the protein intake of the patient along with the other nutritional components needed. The importance of maintaining the serum protein level of such patients has been emphasized by Munro.<sup>7</sup> Figures 438 and 439 illustrate such a case. The patient had a transverse myelitis and had had bedsores for a number of weeks. Her protein concentration in the serum was 6.5 grams per 100 cc. In this instance the deficiency was met by the administration of 75.0 grams of a lactalbumin hydrolysate daily for 120 days. At the end of this period her serum protein concentration was 7.6 grams per 100 cc. The ulcers improved

rapidly though over three months were required before they had healed completely.

The value of protein in liver regeneration has likewise been stressed. By means of a diet high in protein and carbohydrate and low in fat, Ravdin and his associates<sup>9, 10</sup> were able to condition the liver of both animals and man in preparation for anesthesia and operation.



Fig. 439—Same patient after administration of lactalbumin hydrolysate for 170 days.

#### HYPOPROTEINEMIA IN THE POSTOPERATIVE PATIENT

In the surgical patient we frequently have to contend with a pre-existing state of malnutrition. This is particularly true in lesions of the digestive tract in which a "lack" type of hypoproteinemia develops and in patients with chronic draining empyema in which a "loss" type of hypoproteinemia develops. Some patients such as those with liver injury may exhibit a failure to use food nitrogen normally for plasma protein production.

Protein deficiency is often accentuated by operative procedures or by accidents if they have occurred. The significance of operation is to some extent brought out in Table 1, in which it is observed that the average patient admitted for study had only a negligible loss in weight, whereas those who were operated on almost always showed a substantial loss in weight. While a part of this may be due to a few hours' starvation before operation and to a restricted intake in the

postoperative period, it is also due in part to a nitrogen breakdown or catabolism which commonly follows the operative procedure. This catabolism can be reproduced in animals by inducing inflammation either with bacteria or simply by the subcutaneous injection of turpentine which causes the formation of a sterile abscess.<sup>11</sup> Of particular interest in this connection are the studies of Cuthbertson<sup>12</sup> and Howard<sup>13</sup> in which it has been shown that there is an active breakdown of nitrogen for a period of perhaps ten days following the fracture of a long bone. This loss is apparently too great to be accounted for by the local destruction in the affected limb. A similar loss apparently occurs after severe burns<sup>14</sup> and after major operations.<sup>15</sup> However, in most instances it is possible by special feeding technics to replace the loss after major abdominal operations, whereas attempts to do thus in patients with fractures of long bones have generally failed, the patient increasing his nitrogen output as his medical attendants increase his nitrogen intake.

After special types of operations such as gastric resections and gastroenterostomies it is frequently desirable not to feed the patient very much by mouth for several days. Thus the negative nitrogen balance is accentuated on the one hand by a deficient intake and on the other hand by an increased output resulting from the effect of the operation. Minor additional factors are, of course, the blood and plasma loss during the operative procedure and shortly afterwards. If any liver damage is sustained, and it is known that there is frequently measurable impairment of liver function following major surgical procedures,<sup>16</sup> this too may be expected to increase the demand for nitrogen.

**Importance of Maintaining Serum Protein**—It is, therefore, readily seen that maintenance of the protein nutrition in surgical patients is a very difficult and at times an extremely urgent problem. Unfortunately it is most difficult, as a rule, in those patients in which it is most urgent that suitable protein or protein derivatives be supplied. During the past few years much work has been carried out on this subject. In previous communications from this clinic<sup>17-18</sup> emphasis has been placed on the importance of maintaining the serum protein concentration, especially in gastric patients. Perhaps the most satisfactory method in the past has been the use of the *orojejunal* route<sup>19</sup> or its more recent modifications. The arrangements of the tube for this purpose are shown in Figures 440 and 441.

**Parenteral** methods of providing the nitrogen requirement are fairly satisfactory for short periods in patients with good veins, but it is difficult simultaneously to supply an adequate caloric intake. It is, of course, fundamental that the caloric intake be maintained above basal levels if the protein administered is to be utilized for tissue metabolism. In general it may be said that if the caloric intake is not provided the



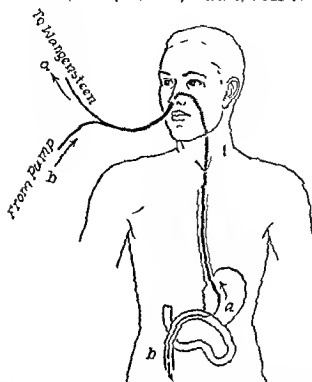


Fig 440 -Nasal tube arrangement for protein administration in postoperative patients

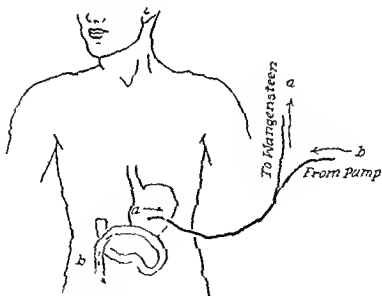


Fig 441 -Arrangement of tube for protein administration after gastroenterostomy

proteins administered will be broken down for their caloric value, though extremely high nitrogen intakes may produce positive nitrogen balance in some patients for as long as five days in spite of a negative caloric balance

**Amount of Protein Needed.**—During the past eighteen months a series of fifty patients undergoing gastrectomies was studied on various feeding regimens. The average daily nitrogen balance during a five-day run in the early postoperative period was analyzed with respect to the average intake of food nitrogen and the average caloric intake in

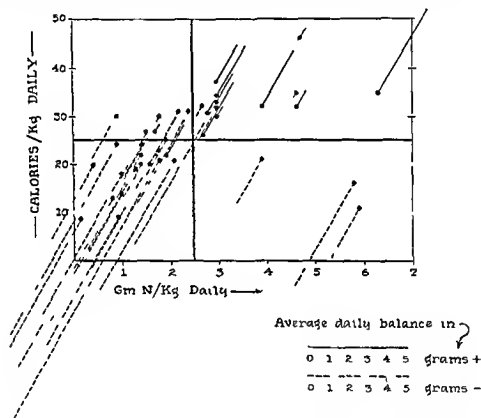


Fig 441—Nitrogen balance in postoperative patients receiving oral or jejunal feedings

calories per kilogram of body weight. The results of this analysis are shown in Figure 442. Positive balances are represented by solid lines extending upward and to the right from the dot which indicated the nitrogen intake and the caloric intake. Negative balances are shown by the dotted line extending downward and to the left. It will be readily seen that most of the positive balances fall in that group of patients which received at least 0.30 gm of nitrogen per kilogram of body weight per day and not less than 30 calories per kilogram of body weight per day. When this amount was consumed a large

majority (70 per cent) of the patients studied were kept in positive nitrogen balance during this early postoperative period

It is difficult to measure the advantage to patients of such a regimen. One can only say that they did well clinically and that their recoveries were seldom marred by postoperative complications.

Figure 443 is a similar chart showing the results with parenteral feedings. This group of patients differed from the other group in that they were not all postoperative and, therefore, it might have been expected that their nitrogen requirements would have been somewhat

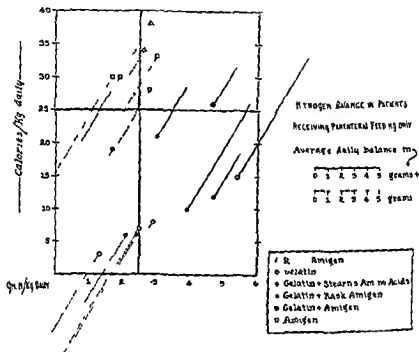


Fig. 443—Nitrogen balance in patients receiving parenteral feeding

less difficult to meet. While perhaps the series is too short to draw any conclusions, it is noteworthy that three patients receiving well above the minimum caloric requirement and receiving a nitrogen allowance above 0.25 gm of nitrogen per kilogram of body weight per day, were all in negative balance. The positive balances were obtained by increasing the nitrogen intake to the range of 0.39 to 0.54 gm of nitrogen per kilogram of body weight per day.

No two surgical patients are exactly alike and it is not to be expected that any one formula can be laid down which will be a safe or satisfactory guide in all instances. An intake of at least 0.30 gm of nitro-

gram per kilogram of body weight per day and at least 30 calories per kilogram of body weight per day would seem desirable during the postoperative period if nitrogen balance is to be maintained

While it is impossible to define all of the factors which affect nitrogen balance in surgical patients, many physicians have been impressed by the fact that the patients with obvious nutritional deficits often seem to retain nitrogen more readily than patients in better nutritional condition

#### ADMINISTRATION OF PROTEIN

Many preparations are available for the nutrition of surgical patients and various routes are available by which these preparations may be administered. Obviously, the majority of patients can take their food by mouth. Unfortunately, however, the most acute deficiencies generally occur in patients who for one reason or another cannot take much nourishment by the alimentary route. In the case of the gastric lesions it is frequently possible to place a tube in the jejunum at the time of operation which will permit the uses of the absorptive reaches of the alimentary tract even though the stomach cannot be used. In other instances it is preferable to use the intravenous route. Casein hydrolysates have been placed on the market by at least two manufacturers and experience with the use of these preparations has been increasingly satisfactory, though febrile reactions still occur at times and nausea or vomiting is apt to supervene if the administration is too rapid. The fundamental difficulty in meeting the complete nutritional requirements of a patient by the parenteral route is that the simple easily purified substances have relatively low molecular weight. If the solutions are concentrated they are also hypertonic, and their continued administration is prone to result in phlebitis and occlusion of the vein. If on the other hand isotonic solutions are used very large quantities of fluid are necessary in order to administer sufficient amounts. There is a striking difference in the tendency of patients to develop so-called chemical phlebitis and it has been possible in a number of patients to avoid phlebitis and still give a moderately concentrated solution composed as follows

175 gm protein derivative  
400 gm carbolhydrate  
8.5 gm sodium chloride  
Water q.s. ad 3500 cc.

For tube feeding various mixtures have been advocated. The ordinary gastrostomy mixture contains relatively large amounts of fat and if for any reason this seems undesirable relatively low fat gastrostomy mixtures can be made up as follows

Skim milk	500 cc
Skim milk powder	50 gm
Cottage cheese	50 gm
Soybean flour	50 gm
1 egg	
+ sucrose to make desired calories	
This equals Protein	70 gm.
Fat	18 gm
Carbohydrate	58 gm
+ carbohydrate supplement in the sucrose	

If such mixtures are to be injected into the jejunum it is again important that they should not be hypertonic, as hypertonic solutions are prone to set up a diarrhea when injected into the jejunum. We have, therefore, preferred to give the carbohydrate in the form of dextrin or starch rather than in the form of glucose or cane sugar for jejunal administration.

As the vitamin requirements in surgical patients have been discussed recently in a number of publications they need not be referred to here. However, it is important to emphasize that these requirements may be considerably greater in certain categories of surgical patients than in the general population<sup>14</sup> and we have found it expedient to give liberal amounts of thiamine, nicotinic acid, riboflavin, menaquinone and ascorbic acid to critically ill surgical patients.

### CONCLUSIONS

1 Surgical patients present a difficult problem in protein nutrition because either their pathologic lesions or their operative treatment frequently interferes with normal ingestion of food.

2 Injuries and operations apparently set up a process of protein catabolism in the body which accelerates nitrogen output.

3 The protein nutrition of surgical patients is a matter of urgency because of the mounting evidence that hypoproteinemia predisposes to certain postoperative complications whereas improved protein nutrition may have a strikingly beneficial effect.

4 Data are presented to indicate that a protein intake equivalent to at least 0.30 gram of nitrogen per kilogram of body weight per day accompanied by a caloric intake of at least 30 calories per kilogram per day is needed in the immediate postoperative period to keep the majority of patients in nitrogen equilibrium. If nutrition is to be carried on by parenteral means even larger amounts of nitrogen appear to be required. While the nutritional problems of the patient who cannot eat may take time and tax the institutional resources very severely the importance of meeting these requirements adequately cannot be overemphasized and the results are generally evident to the clinicians who follow these patients.

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## PREOPERATIVE AND POSTOPERATIVE TREATMENT OF THORACIC SURGICAL CASES

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WITHIN the past decade the results following the surgical therapy of lesions involving the thoracic viscera have improved considerably. Whereas a quarter of a century ago the thorax was opened with considerable temerity, at the present time thoracic operations are done frequently and with an astonishingly low mortality rate. Although many factors have been responsible for this decrease in mortality rate, one of the most important is the careful preoperative preparation of these patients. It is now realized that the thoracic surgeon must not only know the pathology of thoracic lesions and the principles of surgery in general, but he must also have a fundamental and comprehensive understanding of the physiology of the thoracic viscera. These structures are located in a relatively fixed cage in which there is a negative pressure. Any sudden alteration in these factors may be detrimental and hazardous.

### PREOPERATIVE TREATMENT

**Systemic Treatment**—Most of these patients are debilitated as a result of a long standing suppurative process—that is, nontuberculous pulmonary infections such as pulmonary abscess or bronchiectasis—or because of pulmonary tuberculosis or neoplastic disease involving the bronchi, pulmonary parenchyma, or other intrathoracic viscera. In neoplasms, there is frequently a superimposed infection, which tends to increase the debility. Because of the depletion of his systemic reserves the patient who is to undergo a thoracic operation requires systemic therapy to reestablish normal equilibrium and balance. Careful determination of the blood constituents and of the plasma protein level should be made in order to correct deficiencies before major surgical procedures can be undertaken.

In the presence of anemia, *whole blood transfusions* should be administered preoperatively. No elective surgical procedure on thoracic viscera should be attempted without reestablishing the normal blood level and it is a rule in our Clinic to use sufficient whole blood pre-

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operatively to attain the erythrocyte count of at least 4,500,000. In all patients who have received blood transfusions previously, it should be determined whether or not their blood is Rh negative, in order to prevent severe reactions following transfusion, in an individual who has become sensitized to the Rh factor. A patient with a suppurative process is liable to have hypoproteinemia as a result of exudation into the suppurative process with loss of considerable protein. Not only is estimation of the total plasma protein level imperative, but it is also important to determine the quantities of the component albumin and globulin fractions. Patients who have had a long-standing suppurative process involving the thoracic viscera, particularly the pulmonary parenchyma, often have an extremely diminished albumin fraction and an increased globulin fraction. When such a condition exists, there is a greater likelihood of transfusion reaction, therefore, the normal albumin globulin ratio must be reestablished before repeated transfusions are given and before a major operation is contemplated. Severe transfusion reactions frequently occur when there is a reversal of the albumin globulin ratio of the recipient's serum, probably because of pronounced rouleaux formation.

The *reestablishment of a normal plasma protein level* is imperative because hypoproteinemia retards wound healing and favors infection. The former results from deficient deposition of fibrin at the wound site and from wound separation because of the associated nutritional anemia. The plasma protein level can be restored to normal by the ingestion of a high protein diet by the intravenous administration of amino acids or plasma. In such instances a high carbohydrate diet is desirable to protect the proteins from being utilized to maintain normal metabolism. The daily caloric intake of these patients should be high that is, 4000 calories or more, as most of them have increased metabolism because of infection or invasion by neoplastic disease. Since many of these patients have anorexia, this frequently is difficult. The administration of thiamine chloride in relatively large doses of from 5 to 10 mg three times a day will frequently stimulate the appetite sufficiently to permit ingestion of a high caloric diet.

In all patients with hemoptysis the *prothrombin level* should be determined, because occasionally bleeding from bronchiogenic lesions will be associated with hypoprothrombinemia. Only by the reestablishment of the normal prothrombin level can the hemorrhagic tendency be eliminated. The hypodermic administration of synthetic vitamin K (menadione) in large amounts, usually 10 to 20 mg two or three times a day, will correct this deficiency in a short time. We recently saw a patient with bronchiogenic carcinoma manifested solely by profuse hemoptysis which was so severe that, upon admission to the hospital, his erythrocyte count was 2,700,000 and his prothrombin level was 30 per cent. After the administration of 20 mg of menadione



three times a day, the prothrombin level returned to normal and his blood deficiency was corrected preoperatively by the transfusion of 5 liters of blood.

In all ulcerative lesions and in patients with infection the likelihood of a *vitamin C deficiency* must be considered. Several years ago we observed that patients with ulcerative processes generally have a vitamin C deficiency so that we now routinely administer vitamin C preoperatively to all patients with infection or ulcerative processes. Since most lesions involving the thoracic viscera fall within this category we give ascorbic acid routinely, in amounts of 50 to 100 mg three times a day preoperatively for a period of four to seven days. Ascorbic acid deficiency delays wound healing by interfering with the normal deposition of collagen.

**Bronchoscopy**—Special preoperative procedures are indicated in these patients. Most of them should be given the advantage of bronchoscopic examination and drainage. In all lesions involving the bronchi and especially those communicating with the bronchus, bronchoscopy is essential even though it may appear that nothing can be learned

to obtain pieces of tissue for microscopic examination. In suppurative lesions of the pulmonary parenchyma, the bronchoscopist is able to dilate the opening between an abscess cavity and the bronchus. This will facilitate drainage and thus stop the devastating effect of continued toxemia and resulting absorption from 'pent up' purulent secretion. An extremely septic patient frequently presents an entirely different appearance after simple bronchoscopic aspiration of a pulmonary abscess or dilatation of its orifice. Whereas a lesion involving an upper lobe of the bronchus originally may not be in the field of vision of the bronchoscopist, occasionally following the initiation of artificial pneumothorax resulting in the downward displacement of the upper lobe, a lesion previously invisible becomes visible bronchoscopically. This makes it possible to obtain biopsies from lesions in the upper lobe after pneumothorax.

**Bronchography**—Bronchography is an excellent supplemental preoperative measure to bronchoscopy. In fact, we have had a number of instances in which bronchoscopy was of no value in the diagnosis of an intrabronchial lesion, whereas bronchography was responsible for the diagnosis. This is particularly true in lesions of the upper lobe and in those located in the periphery beyond the view of the bronchoscopist. Bronchography, of course, is absolutely imperative in suppurative diseases of the chest, particularly bronchiectasis. No patient with bronchiectasis should ever be submitted to thoracotomy until there has been complete bronchographic mapping of the entire bron-

chial tree in order to determine preoperatively how much of the lung should be removed. It is impossible at the time of operation to tell whether a particular segment of lung is the seat of bronchiectasis or not unless there is associated atelectasis or pneumonitis. Bronchographic mapping must be carefully done, preferably by inserting into the trachea a catheter through which the contrast substance is introduced into the bronchi under fluoroscopic control. In this way one can be sure that the contrast substance gets into the desired area, and the roentgenogram can be taken when the desired filling has been obtained.

**Chemotherapy**—In patients with suppurative disease of the thoracic viscera, the danger of postoperative infection of the pleura is considerable. Whereas, formerly the incidence of postoperative empyema following lobectomy for pulmonary abscess or bronchiectasis was extremely high, recently it has been materially reduced by the preoperative and postoperative administration of *penicillin*. White and his associates<sup>2</sup> were the first to show that penicillin administered in this way diminishes the incidence of postoperative infection satisfactorily, an observation which we have been able to corroborate. Blades,<sup>3</sup> on the other hand, reported that in his series the incidence of postoperative infections was about the same whether penicillin was used or not. For a time, it was difficult for me to explain the discrepancy between the results which Blades obtained and those obtained by White and us. I believe that this discrepancy may be due to the fact that Blades' experience is limited entirely to men in the Service, all of whom had probably received penicillin previously. It is possible that many, if not most, of these patients had infections which were penicillin fast and, therefore, were not benefited by the preoperative administration of bactericides. On the other hand, our patients in civilian practice up to the present time have not had the advantage of unlimited use of penicillin, and it is possible that the excellent results which we have obtained have been due to the fact that their infection had not become penicillin fast.

Although the preoperative and postoperative administration of penicillin is not a panacea in the prevention of postoperative infection, it has materially decreased its incidence and, at the present time, postoperative infection is the exception rather than the rule. Generally, we administer 15,000 units every three hours intramuscularly for approximately a week before the contemplated operation and continue this postoperatively for a week or ten days. Absence of infection and primary healing are the rule under this regimen. Previously, we gave sulfadiazine, 1 gm. every four hours for three or four days preoperatively, or until a level of from 6 to 8 mg. per 100 cc. of blood had been obtained. Now we use the sulfonamides only if penicillin has not produced a satisfactory fall in temperature. In some instances we have combined penicillin with the sulfonamides but only when there

has been an insufficient fall in temperature following the administration of penicillin alone.

**Artificial Pneumothorax.**—In all patients with intrathoracic neoplasms, irrespective of their location, the preoperative induction of artificial pneumothorax is valuable for several reasons. It permits the thoracic surgeon to plan his operative procedure by determining the presence or absence of adhesions, and, if present, their exact location. If there are dense adhesions in the posterolateral portion of the thorax, a posterolateral operative approach is desirable in order to facilitate the division of adhesions under direct visualization. Of equal importance in patients with bronchiogenic neoplasms on whom pneumonectomy is contemplated is collapse of the lung produced by pneumothorax. By compression of the pulmonary capillary bed gradually over a period of days, the cardiovascular apparatus becomes readjusted so that the sudden shunting of all the blood through the opposite pulmonary capillary bed concomitant with extirpation of the lung will not produce any particular disturbance in the cardiovascular function. This is particularly desirable in cases of bronchiogenic carcinoma in older people who are apt to have a diminished cardiovascular reserve. Artificial pneumothorax is usually not done in patients with suppurative diseases of the lung for two reasons: first, usually it is not possible because of the synechia of the pleural cavity, and, second, because of adhesions between the lung and thoracic wall there is danger of unroofing an underlying localized suppurative process when the lung is collapsed. Generally, these lesions occur in younger persons in most of whom the posterolateral approach is used so that the need for collapse of the lung and visualization of adhesions is less important.

**Aspiration.**—Patients with pleural suppurative processes should not be operated upon until one is sure that there is fixation of the mediastinum. As originally emphasized by the Empyema Commission the danger of performing open thoracotomy at a time when the mediastinum is not fixed is considerable. Repeated aspirations of the pleural effusion in order to relieve cardiorespiratory embarrassment is essential as a preoperative procedure. After the fluid has become purulent and sufficient time has elapsed to stabilize the mediastinum, open thoracotomy can be done with impunity.

**Ambulation and Vital Capacity.**—It is desirable to have the tuberculous patient who is to undergo thoracoplasty ambulatory for a period of time before the contemplated operation. Since thoracoplasty is usually done after a period of conservative treatment of bed rest, too frequently a patient who has been in bed for some time is subjected to thoracoplasty without being allowed to be out of bed prior to operation. Undoubtedly, the effort of getting out of bed and being up and about exerts a beneficial effect on the body generally and favors healing processes. It has been our experience that if this is not

observed, frequently there is interference with wound healing, probably because of poor nutrition in patients confined to bed for a long time. The careful preoperative determination of the vital capacity of patients who are to have thoracic operations is important, especially in the tuberculous patient. Any major surgical procedure should be undertaken with considerable caution unless the vital capacity is over 1200 cc.

#### POSTOPERATIVE CARE

**Bronchoscopic Aspiration**—Immediately after a thoracic operation, particularly if there is any secretion in the tracheobronchial tree, bronchoscopic aspiration should be done. This is extremely important, because most of these patients have considerable secretion in the trachea and bronchi and, if the excessive amount can be removed by bronchoscopic aspiration, it will save a great deal of effort on the part of the patient in attempting to bring up the material. It will also greatly minimize the danger of bronchial obstruction and atelectasis.

**Position of Patient**—Upon the patient's return to bed, he should be placed in the horizontal position or, if there is much secretion, in the Trendelenburg or head down position. The latter facilitates gravitation of secretions into the upper respiratory passages and ready evacuation. This position should be maintained until the patient has completely recovered from anesthesia and shock. Shock rarely occurs and can almost invariably be prevented by the administration of blood during the operation. In the presence of shock, however, the head-down position should be maintained because it tends to prevent anemia of the cerebrum. The patient is generally placed on the operated side. This is helpful because it tends to immobilize that side and also does not interfere with aeration of the contralateral, or good, side. Under no conditions should the patient lie on the unoperated side because of the danger of interference with respiration by compression of the uninvolved lung. As soon as the patient has completely recovered from the anesthetic and there is no evidence of shock, a sitting posture should be assumed because this facilitates breathing and is more comfortable.

**Prevention of Circulatory Stasis**—In most patients who have thoracic surgical procedures for destructive lesions, especially the older ones with cardiovascular disease, intravenous clotting, especially phlebotrombosis, is apt to occur. Although little can be done to prevent changes in the blood constituents which favor clotting, a great deal can be accomplished by overcoming the principal precipitating factor—circulatory stasis. The application of compression bandages (Ace No. 8 bandages) from the toes to the groin immediately after operation and the institution of active movement of the extremities as soon as the patient is able to do so will minimize or prevent circulatory

retardation of the blood stream in the lower extremities. The encouragement of deep breathing also facilitates movement of the venous blood by increasing the negative pressure within the thorax. These prophylactic measures are particularly important in older patients who have had pneumonectomy for neoplastic disease.

**Oxygen Therapy**—Oxygen should be administered to all patients continuously for twenty-four hours following thoracic surgical procedures. Whereas the Lombard mask is not as efficient as some of the other methods, nevertheless it is well tolerated by the patient and gives satisfactory results. The intranasal catheter and the B.L.B. mask are two of the most efficient methods for oxygen administration. Generally after twenty-four hours have elapsed, oxygen can be discontinued, although if the patient is still somewhat dyspneic, it can be used from time to time.

**Nursing Care**—There is probably nothing more important than meticulous nursing care for the patient who has had a major thoracic surgical procedure, and it is extremely desirable to have nurses who are not only trained in the care of these patients but who are also interested in them. It is important that the patient take deep breaths ten to fifteen times every hour and that he expectorate any secretion which may be present in the tracheobronchial tree. Unless this is watched constantly, the retained secretion is liable to produce closure of the bronchus with resultant atelectasis and associated pneumonia. As coughing is usually painful, the patient is likely not to do so unless urged. It can be facilitated by holding the thorax during the attempted cough.

**Sedatives**—Sedatives should be administered sparingly in cases of major thoracic operations because of the danger of oversedation. Over sedation diminishes the cough reflex and favors retention of secretions. We have found demerol an efficient analgesic and preferable to opiates because there is less decrease in the cough reflex. Usually 100 mg is sufficient to relieve pain and can be repeated every four to six hours as indicated.

**Fluids and Diet**—The intravenous infusions given during operation should be continued in the postoperative period. Since most of these patients have received a liter or more of blood on the operating table, blood is usually not necessary after operation unless there has been considerable hemorrhage. Generally, infusions of 5 per cent dextrose should be continued postoperatively until the patient has received approximately three liters on the first day. This is generally enough to maintain an adequate water balance. By the end of the first day, the patient usually can tolerate sips of tap water without much difficulty. This should be encouraged unless nausea is present. Generally, on the morning of the first postoperative day, the patient is able to take all liquids by mouth and frequently can tolerate a soft diet. The

patient should be permitted to eat as soon as he can, not only to maintain nutrition, but also to improve his morale. Usually the patient is taking a full diet by the evening of the first postoperative day.

**Inhalations**—In the presence of considerable bronchial secretion, steam inhalations to which benzoin has been added will loosen tenacious secretion. The inhalation of steam for ten to fifteen minutes out of each hour will not interfere materially with the administration of oxygen.

**Drainage**—When pneumonectomy has been performed, the thorax should be closed tightly without drainage, because it is desirable that the hemothorax become filled with an exudate containing fibrin which is deposited in the cavity. If, however, lobectomy has been done, dependent drainage should always be instituted because of the desirability of removing secretions within the pleural cavity to favor expansion of the remaining portions of the lung. If penicillin has been introduced into the pleural cavity as is frequently done immediately after operation when the pleura has become contaminated, the drainage catheter should be kept closed for approximately six hours. If penicillin has not been introduced into the pleural cavity, the catheter should immediately be attached to a mild suction of approximately 12 inches of water to facilitate removal of the exudate. This should be maintained continuously. The tube should be allowed to remain in place until the lung has completely reexpanded and filled the remaining pleural cavity. It should then be removed.

**Associated or Postoperative Infection**—If operation is done for a suppurative process, such as bronchiectasis or pulmonary abscess, or if an infection is engrafted upon neoplastic disease, penicillin must be given for approximately ten days after operation in order to decrease the incidence of pleural infection. In the presence of infection in a patient who is penicillin-fast, the administration of sulfonamides, particularly sulfadiazine, is desirable. Postoperative infections are extremely rare following pneumonectomy for neoplastic disease. The use of chemotherapeutic agents before and after operation has materially diminished infection following lobectomy for suppurative disease. Occasionally, however, in spite of active chemotherapy before and after operation, an infection of the pleural cavity will occur and even in spite of catheter drainage instituted at the time of operation, pocketing of the exudate results. In such an instance, open thoracotomy and adequate drainage are necessary to relieve the patient. This complication should be looked for even though its occurrence is rare. Occasionally, following lobectomy for suppurative disease because of suppuration around the bronchial stump the stump opens and there is a communication between the suppurative process and the bronchus. This is practically unknown following pneumonectomy for neoplastic disease.

**Early Ambulation**—Unless there is some definite contraindication, which is unusual, these patients should be gotten out of bed on the third or fourth postoperative day. This not only improves the morale of the patient but also hastens convalescence. We have seen no bad results from early ambulation of patients following thoracic operations but on the contrary have been impressed with their rapid improvement.

Although great strides have been made in the refinement of technique in thoracic surgical procedures, much of the progress in the treatment of patients requiring these operations, and particularly the low mortality rate, are due to meticulous preoperative and postoperative care.

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## PREOPERATIVE PREPARATION AND POSTOPERATIVE CARE OF PATIENTS UNDERGOING UROLOGIC OPERATIONS

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### GENERAL CONSIDERATIONS

IN the preoperative preparation of urologic patients a careful scientific, diagnostic study is the first essential. From this may be determined the nature of the disease, to what extent this has influenced the function of the genitourinary tract and whether or not it has affected other parts of the body. It will also suggest the nonoperative treatment which will provide maximum improvement before operation is performed. Postoperative treatment does not end with the patient's discharge from the hospital. Periodic observations and treatment for many months afterward are necessary to insure the best results.

The preoperative study entails a careful general as well as urologic history and physical examination. Chemical and microscopic examinations of the urine and blood studies, including serology, should be routine for all cases. *Abnormal findings often indicate the necessity for special examination depending upon the disease and parts of the genitourinary tract affected by it.* In the routine study of the urine, if pus is found in the centrifuged sediment, supplementary cultures should be done to determine the type of organisms involved. Infection which complicates many surgical diseases of the urinary tract, may at times be difficult to eliminate before operation. On the other hand by appropriate application of urinary antiseptics infection may be sufficiently controlled so that complications arising from it during the postoperative period may be reduced to a minimum or eliminated entirely. Routine studies include: white, red and chloride, serum phosphorus and carbon dioxide combining power. This includes total estimations, blood

Another routine study for all surgical cases is estimation of renal function. The combined function of the kidneys may be estimated by phenolsulfonphthalein and concentration tests and should be supplemented by blood nonprotein nitrogen or blood urea nitrogen tests.

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It is desirable in all cases and essential in some to obtain a comparative value of the two kidneys. If the combined function tests are normal, the differential function may be estimated by intravenous urography, which will often supply all the information required regarding the condition of the upper urinary tract. We feel that intravenous urograms should always be made before other differential renal function tests requiring cystoscopy. Roentgenograms that are diagnostic should be an ironclad requirement. The preliminary preparation for obtaining roentgenograms is an important factor. It is our custom to give 2 ounces of castor oil at bedtime and restrict fluids up to the time of examination the following morning. It will be found that in ambulatory patients with good renal function, diagnostic urograms can be obtained in about 90 per cent of cases. Bed patients, on the other hand, present a much more difficult problem. It is often impossible to eliminate enough gas from the intestinal tract to obtain adequate visualization. In such cases, if the disease is one that requires knowledge of the comparative value of the two kidneys, phenolsulfonphthalein test and blood chemistry will have to be supplemented by cystoscopy and differential renal function with indigo carmine or phenolsulfonphthalein.

In many patients it will be found that the preoperative study completes the preparation for operation, others will require treatment to eliminate clinical evidence of infection to improve renal function, to restore proper fluid balance and to stabilize the cardiovascular system. Patients with a positive history or clinical evidence of cardiovascular disease at the time of examination and all those past the age of 50 years should have a complete medical study. We do not believe that an electrocardiogram ordered by the urologist is sufficient to fulfill this requirement. The responsibility for this study should be shifted to the internist, who is much more capable of judging the ability of the patient to stand the planned operative procedure and the necessity of preoperative treatment of the cardiovascular system. Obviously, all patients with clinical evidence of cardiovascular disease should be stabilized before being subjected to operation.

Pronounced variation from the normal will indicate treatment necessary before the patient can safely be operated upon. Secondary anemia is often associated with chronic urinary infection as well as with cases of long-standing reduction in renal function. In these cases blood transfusions should be given until the red blood cell count and hemoglobin estimations are within normal limits.

Attention to the gastrointestinal tract as a preoperative measure is also important. Two ounces of castor oil given forty-eight hours before operation will completely eliminate all intestinal contents and reduce considerably the amount of postoperative distention. It also obviates the necessity of elimination from the bowels for two or three days.

after operation, which is an important factor from the standpoint of the patient's comfort

**Fluid Administration**—Patients who are dehydrated when admitted for study require, as a part of the preoperative preparation, adequate administration of fluids until proper fluid balance has been established. Coller and Maddock<sup>1</sup> have shown that 1000 to 1500 cc of fluid is lost during an ordinary operative procedure, this, of course, should be promptly replaced as soon as the patient is returned from the operating room. It is our custom to administer at least 3000 cc. during the first twenty-four hours postoperatively and continue for a longer period in case the patient's gastrointestinal tract will not permit the administration of a portion of these fluids by mouth. In some cases it may be necessary to give much larger amounts, 4000 cc or more. These patients should be carefully watched for signs of developing edema in the scrotum, ankles, abdomen and lungs. Patients with clinical evidence of cardiac disease should be watched through this period by the internist and fluids should be given under his direction.

#### OPERATIONS ON THE KIDNEY

**Preoperative Preparation**—In addition to these general considerations, it is often necessary to meet added requirements according to the disease and the part of the genitourinary tract involved. Surgical diseases of the kidney should be approached in the following manner. First, a complete chemical and microscopic examination of the urine should be done. If pus and organisms are found in the stained sediment, supplementary cultures should be made to determine the type of infection. Differentiation should be made between the ordinary organisms found in the urinary tract and the more troublesome urea-splitting variety. This latter group is often associated with renal stones, produces greater damage to renal function and accounts for a large number of recurrent stones. Second, combined and differential renal function tests should be done. Third, plain roentgenograms followed by excretory urograms should be made. If the films are diagnostic, the presence of two kidneys should be established and their position and any disturbance in normal function or contour should be noted. If a complete diagnosis cannot be made by this procedure, cystoscopy and retrograde pyeloureterography become necessary. Cystoscopy may be desirable in some cases for the purpose of collecting urine from the kidneys for separate studies, and at the same time it is customary to do differential renal function tests. Because of the frequent association of hyperparathyroidism with renal stones, determination of the serum calcium and serum phosphorus blood level is a part of the routine study in all cases of stones in the kidneys. In patients with hyperparathyroidism a comprehensive knowledge of the pathologic process and a coopera-

tive understanding between the general surgeon, internist, radiologist and urologist are essential for the best results

It is often necessary to remove a stone or do a plastic operation on a patient with only one kidney. These cases may be complicated by infection, reduction in renal function and disturbance in other body functions. A situation of this kind serves to emphasize the necessity of caring for the patient as much as possible by improving renal function, administration, drainage by ureteral catheter, urinary infection by the judicious use of drugs, improvement of the patient's blood count by blood transfusion, and stabilization of the cardiovascular system when this seems indicated.

**Postoperative Care**—The postoperative care of patients with renal disease varies with the type of operation performed. If the kidney has been removed and the pedicle well ligated, there should be no danger of secondary hemorrhage. Postoperative care includes fluid administration in amounts sufficient to insure adequate urinary output by the remaining kidney, attention to the gastrointestinal tract, and opiates as required for the patient's comfort during the first forty-eight hours. After that time most patients are quite comfortable. The drain, which is brought out at the posterior angle of the wound, is left in place for at least a week or until the drainage has been reduced to a minimum.

When a kidney is removed for calculous pyelonephrosis, it is often necessary to perform *subcapsular nephrectomy*. In such cases the drain should be left in place for a longer period because, if it is removed too soon, an infected cavity may form within the capsule. The wound in such cases may appear to be healed but will break open and discharge a quantity of pus at intervals for months afterwards. If this occurs, a short posterior incision should be made, the cavity visualized with retractors and the lining removed with a sharp curet or cutting current from the Bovie unit. We have had to do this on several occasions and the results have been uniformly satisfactory. Occasionally, during the performance of subcapsular nephrectomy, it is necessary to leave clamps on the pedicle. Constant and intelligent nursing care is required during the immediate postoperative period and until the patient has sufficiently recovered to cooperate. The clamps should be left on for five full days, loosened at that time and left in place for an additional twenty-four hours. We have seen no bleeding occur after this period and see no reason to take the risk of removing the clamps sooner.

When *pyelotomy* or *nephrotomy* is performed, some urine usually leaks through the wound. A drain should be left in the posterior angle of the wound until this has stopped, usually by the end of the first postoperative week. Drainage of urine for a longer period

may occasionally require the insertion of a ureteral catheter. Even if no obstruction is met, it is good judgment to leave the catheter in place for three or four days and if it is well placed in the pelvis, the wound will become dry during that time. Some edema of the ureteral mucosa may be expected from the retention catheter and a rise in temperature may occasionally follow its removal, but such temperature reactions usually pass off after a few days. The administration of urinary antiseptics during the period the catheter is in place may be of value in reducing these reactions to a minimum.

A *postoperative rise in temperature* during the first three or four days may be expected in nearly all patients having renal operations, but a secondary rise usually means a new infection. This may take place around the kidney and the common site is above the upper pole if drainage of this area has been inadequate. It occurs less frequently around the lower pole and interior to the kidney. A careful search with a stiff Coude catheter or a curved clamp will usually reveal the pocket. Chills and fever may also be caused by pyelonephritis, and in considering this as a possibility it must be remembered that it may occur in the kidney that has not been operated upon. Permitting the patient to lie too much on his good side, thus creating uphill drainage, may in some cases, theoretically at least, predispose to pyelonephritis in the undisturbed kidney.

The possibility of infection distant to the urinary tract should be kept in mind and a thorough search made for it at the same time that infection in the urinary tract is being treated. Infections in the layers of the wound cause surprisingly little trouble, even when gross contamination has occurred during removal of a large pyonephrosis. Now that penicillin is available for general use, it will likely be of value in preventing a great many of these secondary infections. We are using it in the immediate postoperative period at the present time and its use is apparently justified. We believe that it should be tried in both the preoperative and postoperative period even when the cultures are bacillary, as we are not convinced that enough clinical evidence is at hand at the present time to condemn its use in this type of infection.

Another operation on the kidney deserving additional consideration is *nephrotomy for removal of a stone from one of the calices*. In the preliminary studies this procedure will be indicated by a small entirely intrarenal pelvis and an undilated ureter entering the renal sinus. In such cases, the infundibulum leading from the calix is often too narrow to allow the stone to be removed through it without the risk of fragmentation. Nephrotomy necessitated by this situation is usually followed by the same smooth postoperative recovery as ordinary pyelotomy. On the other hand, one must be aware of the possibility of secondary hemorrhage in this type of case. The pres-

ence of infection increases the likelihood of this occurrence. Nephrectomy is usually required for this complication. Large infarcts frequently develop along the edge of the nephrotomy wound and it is useless to hope that bleeding will stop. Transfusion should be given immediately after the first hemorrhage and other donors typed in anticipation of the second hemorrhage, which will usually occur while the surgeon is trying to decide whether or not nephrectomy is necessary. We were confronted with this complication once in a patient with only one kidney. Many blood transfusions, frequent blood counts and constant attention for a period of five days won the battle, but this risk is not justified in a patient with two kidneys. Secondary suture in such cases is not satisfactory.

Another type of case requiring additional consideration is the *care of the nephrostomy tube* which may sometimes be left in for a period of weeks or months, or occasionally as a permanent arrangement. Temporary nephrostomy tubes are used in connection with plastic operations on the renal pelvis and in operations for multiple stones if it is thought that small fragments may have been left. Postoperative roentgenograms at the end of ten days or two weeks should be made and if stone fragments are found, they can usually be easily removed through the nephrostomy opening with a Randall type of stone forceps. If the roentgenograms show no stones, the nephrostomy tube may be removed and as a rule the opening closes the same day frequently without leaking enough urine to soil the dressing. Following plastic operations on the renal pelvis, the nephrostomy tube is left in place until the plastic repair has completely healed and the ureteropelvic junction shown to be functioning well by postoperative roentgenograms made during the injection of diodrast through the nephrostomy tube. This may usually be done about the end of the third or fourth postoperative week. The care of a permanent nephrostomy tube is usually placed in the hands of the patient or some member of his family. A No. 24 or 26 whistle tip catheter is the most desirable type to use. It is held in place by adhesive plaster and may be removed at weekly intervals for cleaning and replaced without discomfort. If the catheter is pulled out accidentally, it should be replaced fairly promptly, as the nephrostomy opening contracts down rapidly and, after a few hours it may be difficult to reinsert. It is desirable in such cases to keep the urine acid. The patient should also drink large quantities of fluid in order to keep the urine dilute. In addition, daily irrigation with boric acid or 1:10,000 solution of potassium permanganate should be done. This combination will reduce the tendency to phosphatic incrustation which forms around the pelvic end of the catheter. If, in the preoperative studies, urine cultures show the presence of urea splitting organisms, we have found that irrigation with Albright's Solution A greatly reduces the viru-

lence of this type of infection. Whether the operation on the kidney has been performed for stone or other disease, the importance of obtaining a sterile urine cannot be stressed too much. This involves (1) measures to relieve stasis, (2) application of urinary antiseptics, (3) forced fluids, and (4) removal of foci of infection.

#### OPERATIONS ON THE URETER

*Preoperative Preparation*—The preoperative requirements for operation upon the ureter include a study of the corresponding kidney to determine any damage that may have been produced by the condition in the ureter requiring treatment. The ureter from the ureteropelvic junction to the orifice in the bladder should be visualized. If the function of the kidney is good and the ureter is not completely obstructed, this may be accomplished by excretory urograms. If complete visualization can be obtained by this means, we believe it to be more accurate than retrograde ureterography because of the spasm that frequently follows the passage of a ureteral catheter. If the operation is to be done for stones, the roentgenograms should be made immediately before the patient is taken to the operating table and plates brought to the operating room for study before the operation is started. This is a safeguard against the stone slipping away from the site of the proposed incision. Failure to observe this simple procedure may be extremely embarrassing in an occasional case.

In some cases it is desirable to pass a ureteral catheter during the preoperative study and in such cases the catheter should be left in place until after the stone has been removed. The purpose of this is to fix the stone in position. Roentgenograms should always be made after insertion of the catheter as the stone may be pushed to a higher level in the ureter or even back into the renal pelvis. An accurate knowledge of the anatomic relationship of the various portions of the ureter is essential, and the preoperative insertion of a catheter for the sole purpose of locating the ureter is not necessary. If one elects to resect a primary tumor of the ureter, careful preoperative studies should prove that the renal pelvis, calices and the ureter above and below the site of the proposed resection are free from growth. The bladder should also be studied for possible transplants.

*Postoperative Care*—The postoperative care of a patient who has had a stone removed from the ureter is the same as that for pyelotomy. Urine may drain from the incision for a few days, but only rarely does it continue long enough to require insertion of a retention ureteral catheter. A Penrose drain should be left down to the site of the incision in the ureter until drainage has stopped, usually by the end of five to seven days. In operations involving the lower third of the ureter, the drain should be so placed that it will not come in contact with the large vessels in this area. We have seen postopera-

tive hemorrhage from the external iliac artery occur when this precaution was not exercised Following anastomosis of the ureter, the catheter used to splint the anastomosis and one that may be used to divert the urinary stream above the site of anastomosis may be removed at the end of ten days If the suture line breaks down extravasation of urine takes place and nephrectomy is required If this situation is encountered in a patient with only one kidney, permanent nephrostomy would be necessary After operations upon the ureter the ureter should be catheterized periodically to safeguard against the development of a stricture at the site of operation After a period of months, if excretory urograms show the ureter to be normal these treatments may be discontinued

### OPERATIONS ON THE BLADDER

**Preoperative Preparation**—Operations upon the bladder whether for removal of a diverticulum or tumor or simple cystostomy preliminary to prostatic enucleation require the same general studies described for renal operations and, in addition, routine cystograms Cystoscopy is supplemented in some cases depending upon the nature of the disease Any associated infection should be treated by the administration of urinary antiseptics and fluids, irrigation of the bladder with mild antiseptic solutions and, in some cases, drainage by a retention urethral catheter during the period of preoperative study It is desirable to remove all clinical evidence of infection before the bladder is operated upon In some cases, of course, this may be difficult to accomplish

**Postoperative Care**—The postoperative management of diseases of the bladder involves chiefly control of bleeding care of the catheter, treatment of infection and administration of appropriate amounts of fluid in order to insure adequate urinary output Bleeding in the early postoperative period may be the result of incomplete fulguration of the base of the tumor or failure to include the mucosa in the suture line in closing the bladder We have found it necessary to reopen and resuture the wound in one case because of bleeding from this failure We have seen late bleeding occur from ulceration caused by the cystostomy tube resting on a large intravesical projection of the prostate In the presence of hemorrhage the bladder should be emptied of clots by irrigating with a large bore Triumph syringe and, if the bleeding continues after the bladder is at rest, it should be stopped either by a suprapubic or transurethral approach depending upon the nature of the condition responsible for it Blood transfusion loses enough blood to justify it, by the administration of glucose and of cases, however, after the bladder has been emptied of clots and completely at rest, the bleeding stops

Appropriate use of opiates helps to keep the bladder at rest, and if bladder spasm can be prevented, hemorrhage will usually not recur.

Trouble with the catheter usually results from its faulty position in the bladder, poor drainage apparatus and inadequate attention on the part of the nursing and house staff. If the catheter does not drain, it is either in too far, not in far enough, or stopped up. The catheter should be brought out at the upper end of the incision in the bladder and the wound in the abdomen. This places it well away from the neck of the bladder and gives it a diagonal course which greatly facilitates closure of the wound after it has been removed. The catheter should be irrigated with a Triumph syringe before the patient leaves the operating room to be sure that it is working. Care should always be taken to see that good drainage apparatus is provided and properly connected to the cystostomy tube. The medicine dropper type of glass connecting tip should never be used. Soft, collapsible rubber tubing that kinks easily affords poor drainage and predisposes to leakage of an excessive amount of urine through the wound. Nursing supervisors and members of house staff who have been properly trained in the care of drainage apparatus will render invaluable assistance in making the postoperative course of these patients more comfortable. Some urine may be expected to leak around the tube, but if the catheter is well placed and proper after care given to it, this will be reduced to a minimum. An excessive amount of drainage through the wound is undesirable as it prevents healing and predisposes to infection. In such cases, a retention urethral catheter may be inserted and this along with the drainage from the cystostomy tube will help keep the wound dry.

As a rule, however, infection in the wound is not a troublesome factor provided the cystostomy tube has been well placed and the space of Retzius adequately drained. Preoperative and postoperative administration of urinary antiseptics will reduce the amount of infection considerably and thus promote more rapid closure of the wound. The drain should be left in the space of Retzius until the wound has satisfactorily healed. After the cystostomy tube has served its purpose it may be removed and at the same time a urethral catheter inserted and left in place until the wound has been dry for four or five days.

#### OPERATION FOR PROSTATIC OBSTRUCTION

**Preoperative Preparation**—The preoperative study and treatment of patients with prostatic obstruction probably has a greater influence upon the outcome of the operation than the preoperative preparation of patients for other types of urologic surgical procedures. A large number of these patients are of advanced years and have changes in the cardiovascular system common to this age group in addition to secondary changes that may have been produced by obstruction.



at the bladder neck. Acute retention of urine is the common emergency created by prostatic obstruction. Prompt relief can usually be accomplished by insertion of the urethral catheter, which should be done without trauma and with surgical cleanliness. This can be made easier for both the urologist and the patient by proper selection of the catheter. A size 16 or 18 prostatic (olive tipped Coude) type of catheter has been most satisfactory for us. If difficulty is encountered, it may be due to strictures, spasm of the external sphincter or acute angulation of the prostatic urethra produced by a large middle lobe. In case of a stricture, a filiform and catheter follower may have to be used. If the difficulty is due to spasm of the external sphincter, the injection of  $\frac{1}{4}$  grain of morphine hypodermically will relax the spasm and allow the catheter to pass without difficulty in the majority of cases. If the difficulty is due to angulation of the prostatic urethra, it may be necessary to use a catheter guide, in which case a Robinson type of catheter would be substituted for the prostatic type. The case in which one of these methods is not successful will rarely be encountered. On the other hand, if a catheter cannot be passed, it must be remembered that acute retention of urine is a surgical emergency that must be handled by one method or another. Suprapubic cystostomy is a justifiable procedure and can be accomplished with little risk if done through a small incision under local anesthesia. Once the bladder is emptied, the emergency is over and continuous catheter drainage is carried on while a complete and unhurried diagnostic study is done.

The question also arises as to whether or not it is safe to empty the bladder completely in the presence of large retention, or whether it is safer to decompress it gradually over a period of from twenty four to forty eight hours. Up to the present time we have seen no complications that could be directly attributed to emptying the bladder completely. On the other hand, we respect the opinion of those who feel that gradual decompression should be done. In addition to the routine blood and urine studies, diagnostic procedures include renal function tests: a complete study of the urinary tract to determine whether or not any secondary changes have been produced by the obstruction; estimation of the size of the prostate; differentiation between benign hypertrophy and carcinoma; and evaluation of the cardiovascular system. Studies of renal function are started by the intravenous injection of 1 cc. of phenolsulfonphthalein and it is our custom to collect one voided specimen at the end of an hour and ten minutes. If the output for that period is 40 per cent or more it is considered that the patient is not retaining a large volume of urine and that renal function is within normal limits. If a low reading is obtained, it is considered that the patient is holding back urine or that he has a reduced renal function and he may have both. A small soft

rubber catheter should be inserted at this point to determine the amount of residual and whatever volume of urine obtained is added to the voided specimen to make up the total phenolsulfonphthalein reading. This test is supplemented by blood urea-nitrogen or blood nonprotein nitrogen estimation. A complete roentgenographic study of the urinary tract will determine whether or not secondary changes have taken place.

A plain roentgenogram of the kidneys, ureters and bladder will settle the question of stones and, in the case of carcinoma, will determine the presence or absence of metastatic lesions in the bones in this area. Cystograms in three positions followed by a fourth anteroposterior film after the opaque medium has been evacuated through the catheter should be routine in all cases of prostatic obstruction. The cystograms will show the size of the bladder and determine the presence or absence of diverticula, and the evacuation film will differentiate between a diverticulum which retains fluid and one which empties with the bladder. In the presence of normal renal function intravenous urograms are desirable but not essential. The findings on rectal examination of the prostate correlated with the findings on roentgenographic studies often furnish sufficient evidence upon which to base judgment as to the most desirable type of surgical approach without resorting to cystoscopy. Cystoscopy should be avoided in these cases unless a complete diagnosis cannot be accomplished without it. Differentiation between benign hypertrophy and advanced carcinoma is usually not difficult, but to rule out a small firm area in the prostate as the seat of primary carcinoma in the preoperative studies is often not possible.

The cardiovascular system in this group of patients is so often diseased that an examination by the internist is an essential part of the preoperative study. Three principal requirements must be met before the patient with prostatic obstruction can be considered ready for operation. First, the renal function must be within normal limits or stabilized at one level or another, second, the patient must be free of all clinical evidence of infection, and third, the cardiovascular system must be stabilized. After the diagnostic study has been completed, it will be found that in many cases the patient is in good condition and may immediately be operated upon. In another group of patients drainage by retention urethral catheter and administration of fluids and urinary antiseptics may be necessary to improve renal function and remove clinical evidence of infection. Patients with a decompensated cardiovascular system are placed under the supervision of the internist until maximum improvement can be accomplished. An occasional case will be encountered in which the preoperative treatment promises to be a long drawn-out affair. In such cases, a small suprapubic tube inserted under local anesthesia is preferable to pro-

longed drainage by indwelling urethral catheter. This allows more freedom from the bed, which is important from the standpoint of pulmonary complications in these old men. Often, apparently 'impossible wrecks' can be restored to fair surgical risks.

*Postoperative Care*—In the postoperative care of prostatic patients, if prostatectomy has been done, in addition to general postoperative care, the first twenty-four hour period involves attention to the hemostatic bag. Tension on the bag may be released at the end of six to eight hours but it is perhaps safer to leave the bag inflated and in place until the end of twenty-four hours, at which time it may be removed under aseptic conditions and a retention urethral catheter inserted. This should be left in place until the wound is closed.

Patients subjected to prostatic resection require strict attention to postoperative hemorrhage and catheter drainage. Bleeding that occurs on the day of operation is usually the result of inadequate fulguration of bleeding points at the time of resection. Frequent irrigations of the bladder to prevent the formation of clots and the administration of opiates to control bladder spasm and mild tension on the hemostatic bag will prove satisfactory in the majority of cases. On the other hand, if active bleeding continues, the patient should be returned to the operating room without delay and under a small spinal anesthetic the clots evacuated and the bleeding points fulgurated. At the same time, strict attention should be given to the patient's general condition, intravenous fluids administered and blood transfusions given when indicated.

Late hemorrhage in cases of prostatic resection usually occurs between the end of the first and second postoperative week. When it does occur the bladder should be promptly emptied of clots through a large stiff catheter by means of a large bore Triumph syringe and if the bleeding is not promptly controlled it should be treated in the manner already described. Strict attention to catheter drainage will in many cases prevent postoperative hemorrhage as well as other complications.

Any patient who has a retention catheter in place (whether before or after operation) and complains of discomfort in the bladder should have the catheter promptly checked. In the majority of cases the discomfort will be found to be due to a full bladder. One of the most inexcusable errors that can be committed by a member of the house staff is to order an opiate over the telephone in this type of case. Patients who have had prostatic resection require more careful attention during the postoperative period than do patients who have had prostatic enucleation. A good functional result should be obtained regardless of the method used to relieve the obstruction. In cases of prostatic resection the patient must be able to urinate with ease, pass a strong forceful stream and empty the bladder completely. In patients who

are able to empty the bladder but have frequency, nocturia, urgency, tenesmus and terminal hematuria, the prostatic urethra should be investigated, usually, it will be found that nubbins of prostatic tissue have been left, especially in the region of the verumontanum, and their complete removal relieves these symptoms. A catheter should be passed through the urethra during the first few weeks after operation and sounds should be passed at intervals over a period of months in order to prevent or treat strictures which may occur after any operation on the prostate, and more especially after transurethral resection.

In the absence of clinical symptoms, urinary antiseptics are not of much value in the early postoperative period but after the prostatic urethra has fairly well healed they may help to accomplish a sterile urine. Usually, however, if the obstruction has been completely removed and the patient has good renal function and there are no other complications, the urine will be sterile by the end of the third postoperative month. Patients with prostatic malignancy are examined at intervals for two reasons: first, to discover recurrence of obstruction and second to relieve pain that may be the result of metastatic lesions. Orchidectomy and the use of stilbestrol delay and may, in some cases, prevent the recurrence of obstruction and are also of value in controlling the pain from metastatic lesions. Deep roentgen ray therapy, nerve sections and finally drugs may be used when hormones are no longer effective.

#### URINARY TRACT TUBERCULOSIS

Tuberculosis of the urinary tract is secondary to a primary focus in some other part of the body, frequently the lungs. These cases require a careful study from that standpoint. Treatment under conditions standardized for such cases should be carried out for whatever period of time is necessary to arrest the activity of the primary lesion. Only in most unusual cases is one justified in removing a kidney for renal tuberculosis before this has been accomplished. The postoperative care of these patients involves chiefly the treatment of discomfort in the bladder and general management of the tuberculous subject. Urinary sedatives, such as pyridium and methylene blue supplemented by instillation of the bladder with sterile olive oil, give considerable relief. Better results would most likely be obtained if every patient who has had an operation for tuberculosis of the urinary tract could spend the following six months in a tuberculosis sanitarium or a longer period if the primary lesions should show renewed activity after operation.

#### URINARY TRACT MALIGNANCY

The preoperative study of patients with malignancies of the urinary tract has for its purpose an accurate diagnosis of the type and loca-

tion of the malignancy, the pathologic grading of the tumor if possible, and whether or not it has metastasized. Roentgenogram of the chest and long bones are routine in the study of tumors of renal cortex, as well as tumors of the renal pelvis and, in the latter type the corresponding ureter and the bladder are carefully investigated for the possibility of transplants. Tumors of the renal cortex are radiosensitive and in some cases, the final results are greatly improved by preoperative deep roentgen ray therapy. In early cases, however, the delay necessitated by the time required for the administration of roentgenotherapy makes one hesitate to use it routinely. We give roentgen ray treatment to all patients following removal of Wilms tumor and, in selected cases, after nephrectomy for hypernephroma. In the preoperative studies of tumors of the bladder, biopsy specimens for pathologic grading are obtained. On cystoscopic examination the gross appearance of the tumor should be noted, its location, the number, presence or absence of edema, measurement of bladder capacity and supplementary cystograms all constitute important parts of the study upon which judgment as to the type of treatment indicated is based. The postoperative care extends over a period of years and has for its purpose the detection of recurrences and appropriate treatment when these are found.

#### COMPLICATIONS OF UROLOGIC OPERATIONS

*Phlebitis* may occasionally develop in the deep pelvic or peripelvic veins in patients who have had operations on the prostate. Discontinuity in this region, low grade fever and a pulse rate out of proportion to the height of the temperature should arouse suspicion and if the corresponding leg is swollen the diagnosis should be fairly certain. This may be confirmed by venograms. Ligation of the involved vein may in some cases prevent a fatal embolus.

*Hiccough* is an unpleasant complication that may follow any operation upon the genitourinary tract. It occurs more often in patients who have reduced renal function. Treatment includes administration of opiates, inhalation of carbon dioxide and attention to methods of improving renal function.

*Abdominal distention*, also known as *paralytic ileus*, may occur in both the stomach and the entire small intestine. It is a great, nothing should be permitted. The patient should be kept intravenously and the stomach should be emptied by insertion of a nasal tube and kept empty by Wangensteen's suction. A rectal tube and a heat tent to the abdomen and flushes assisted by the administration of pituitrin or prostigmine are usually sufficient to afford relief.

*Suppression of urine* may occur and is usually the result of hemorrhage, shock or renal failure. Hemorrhage should be treated by prompt and adequate replacement of blood. Shock should be treated by prompt and adequate replacement of blood. Shock should be treated by prompt and adequate replacement of blood.

by transfusion, infusion and appropriate drugs to restore the blood pressure to normal. Suppression from renal failure should be treated by the intravenous administration of appropriate amounts of fluid supplemented by the intravenous injection of 100 to 200 cc. of 50 per cent glucose. Over a period of several years we have seen an occasional spectacular result from the intravenous administration of 4.285 per cent sodium sulfate solution, 1000 cc. being administered at about the same interval as ordinary infusions of glucose and saline. Careful attention to the blood pressure should be given to all patients with renal suppression regardless of cause.

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## PREOPERATIVE AND POSTOPERATIVE CARE OF THE PATIENT HAVING OPERATIONS ON THE GASTRO INTESTINAL TRACT

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RECENT years have brought many advances in preoperative and post operative care, making the patient a safer risk for surgical intervention, indeed, formidable procedures can now be carried out with little physiologic disturbance. In nearly every instance these improvements have rendered the postoperative period less hazardous and more comfortable. Those patients having gastrointestinal operations have benefited doubly for they are not only better protected from shock and dehydration but a normal or almost normal nutritional status can be maintained now more efficiently than before. Fortunately, a fuller knowledge of gastrointestinal dysfunction after operation has led to a wiser handling of this problem and finally, surgical techniques have become more exact and less traumatizing.

Many problems in preoperative and postoperative treatment are common to all types of operation. Shock, fluid balance, nutrition and wound healing are concerns not peculiar to gastrointestinal surgery. However, nutritional problems naturally occur more often when the stomach or intestines are diseased and the disturbance is likely to be more severe. Experience has taught that a superficial examination sometimes fails to reveal the extent of such abnormal changes and laboratory tests must then be used to determine them accurately. Then too the obvious difficulty in taking food after operations on the gastrointestinal tract complicates the problem of handling these already handicapped patients. This is best illustrated by the already starved patient and the diabetic person.

### PREOPERATIVE PREPARATION

**General Measures**—The preparation of the patient for operation should begin with a survey to determine the presence and extent of other abnormalities which might influence the outcome. For our purposes this can be limited to correctable pathologic conditions such as dehydration, anemia, hypoproteinemia, avitaminosis and urinary re-

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tention Cardiac conditions and nephritis might be included in this category to the extent that they are correctable Only the problems that have a specific relationship to gastrointestinal disease will be discussed at some length in this paper

**Nutritional Status**—The body weight is frequently sufficient to determine malnutrition but sometimes the weight lost during the present illness is more significant Blood studies should be done in every case Hypoproteinemia is difficult to determine clinically unless edema is present although it may be guessed from other evidences of starvation If there is any evidence of malnutrition, estimation of plasma proteins is always indicated The need for vitamins is more difficult to determine unless the patient presents clinical signs, for quantitative estimations are impossible or difficult except for ascorbic acid (vitamin C) Since the important vitamins can be easily supplied, it is customary to give them preoperatively to all patients with any disturbance in nutrition, even though it is minimal Such an attitude is not unreasonable, being based on the frequent occurrence of frank deficiencies in these patients and their known beneficial effect on the general condition and on wound healing Vitamin C deficiency particularly, influences the latter but other nutritional factors, such as hypoproteinemia, also play a part

The correction of dehydration and nutritional deficiencies is our first duty in the immediate preoperative preparation An adequate diet is, of course, the best way to accomplish this although other supplementary measures are often necessary because the disease makes proper intake and utilization impossible Sometimes, too, the period of rehabilitation can be shortened by using every approach to the problem—an important consideration when delay is contrary to the best interest of the patient Blood transfusion serves several purposes It is the quickest way to correct anemia but it also supplies protein and is therefore useful in hypoproteinemia, however, for this alone, plasma is as effective The diminished plasma proteins are not always restored in direct proportion to the plasma administered This seems to depend on the amount of depletion An explanation is offered in the work of Sachar, Horvitz and Elman<sup>1</sup> who found evidence that a loss of 1 gm of protein from the plasma indicated a concomitant loss from the tissues of about 30 gm When body proteins are being replenished the partition is approximately the same, the tissues taking about thirty times as much as is retained in the plasma This accounts for the slowness with which severe hypoproteinemia is overcome The amount of protein supplied by plasma or blood transfusions can be estimated easily, being about 7 gm for each 100 cc Obviously, large amounts will be necessary to restore the plasma proteins to normal when the deficiency is great Commercial amino acids especially prepared for this purpose have proved valuable These building stones of proteins are



given intravenously in a 5 per cent solution with 5 per cent dextrose. Few reactions will occur if administered slowly. Although exactly how much is transformed into protein is not known there is much evidence that it is possible to keep patients in nitrogen balance by this method. Amino acids can also be given by mouth in powder form.

Correction of vitamin deficiencies has been rendered fairly easy by the large number of preparations both for oral and parenteral use. If there is any question of malnutrition or specific vitamin deficiency commercial vitamins should be given preoperatively. The accompanying tabulation by Jolliffe and Smith<sup>2</sup> may serve as a guide.

DAILY DOSAGES OF VITAMINS FOR SPECIFIC DEFICIENCIES

Deficiency	Mild	Moderate	Severe
Vitamin A	100 000 U (m)	200 000 U (m)	200 000 U (m)
Vitamin D	2 000 U (m)	2 000 U (m)	2 000 U (m)
Thiamine	10-30 mg (p)	20-50 mg (p)	50-3000 mg (p)
Riboflavin	10 mg (m)	10-20 mg (m)	20-50 mg (m)
		10 mg (p)	10 mg (p)
Nicotinic Acid	300-500 mg (m)	500-1 000 mg (m)	1 000 mg (m)
or			
Nicotinamide			200 mg (p)
Ascorbic Acid	500 mg (m)	500-1 000 mg (m)	1 000-2 000 mg (m)
			500 mg (p)

(m) by mouth (p) parenterally

Dehydration need not be discussed at length here although it is a most important part of management. It should be remembered that some cases of gastrointestinal disease present chronic dehydration which is not evident to either patient or physician. Such states often invalidate blood counts, plasma protein determinations and other chemical studies by producing a hemoconcentration. Many pitfalls can be avoided by a realization of these possibilities.

**Preparation of the Stomach.**—Experience makes it plain that operations can be made safer and easier when the hollow viscus involved is empty and as free from bacteria as is practical. Ordinarily the first can be accomplished if nothing is given by mouth for several hours prior to operation. Orders usually read "nothing by mouth after midnight" when the operation is scheduled for the next morning. However, if any degree of obstruction exists it is wise to lavage the stomach and leave the tube in place a short time before operation. With moderate obstruction it is customary to insert the tube and wash out the stomach the night before and the morning of operation. Because some patients with almost complete obstruction have large dilated stomachs it is often desirable to leave the tube in place and apply

continuous suction for at least twenty-four hours. On the other hand there is little reason to bedevil the patient with these measures when the stomach empties rapidly and secretes quantities of free acid—a situation usually present in the patient with duodenal ulcer who is to have gastric resection. Most surgeons now prefer a tube in the stomach at the time of operation even though there is no stasis. This does give better control over the stomach and allows removal of liquid or air that may have accumulated since the morning lavage.

It has long been known that the normal fasting stomach is relatively sterile. Conversely, the bacterial content increases with obstruction and reduction in the acid secreted. The normal condition in an abnormal stomach can best be stimulated by preventing stasis and supplying hydrochloric acid up to a maximum of 0.5 per cent—approximately the strength in pure unaltered gastric juice. In the absence of obstruction but with a low acid secretion, particularly of free acid, the patient should be given 15 to 30 drops of dilute hydrochloric acid with each meal.

As already stated, in all patients with any degree of obstruction, the stomach should be lavaged before operation and in most instances the tube should be left in place. The absence of free acid is indication for the addition of hydrochloric acid to the water so used, making it a 0.5 per cent solution. Those patients with obstruction should be given a special diet that can pass into the intestine or, if this is not possible resort must be had to suction by tube. The degree of obstruction will determine which measure is required. It is often possible to carry a patient with partial obstruction along fairly well by limiting his intake to fluids. Lemonade provides fluids, carbohydrates and sugar, in addition, hydrochloric acid may be added in quantities necessary to make the final solution 0.5 per cent. A pitcher of this can be set by the patient's bed and he is told to drink as much of it as he can. Eggs, thin broth, gruels, thin porridge, cereals, custards and gelatin can be added as tolerated. The patient who vomits on such a diet has a high degree of obstruction and operation should not be long delayed.

**Preparation of Small Intestine**—The main preparation of the small intestine consists in having it relatively empty for operation. This may be accomplished in three ways, depending on the degree of stasis present. If intestinal function is essentially normal, withholding everything by mouth will usually insure the desired result. Ordinarily, a light evening meal is served and water is allowed until midnight, but if one is particularly anxious to have a deflated intestine, these periods may be lengthened by four to six hours. Water in moderate amounts produces comparatively little distention although the air taken in with it can bring about this undesired result. Another method of reducing the contents of the small intestine is continuous gastric suction, the limitations of which are best realized if the mechanism of its action

is understood. Thus, the most important effect on the small bowel is obtained by removing most of the liquids poured into the stomach. In this way, the material reaching the intestine is drastically reduced. The second way is by removal of the material brought into the stomach by reverse peristalsis. However, unless well developed obstruction is present, the amount of material removed from the jejunum and ileum is not great. Here again, it is true that some benefit is obtained by depriving the lower tract of that amount of bile and pancreatic secretion that is regurgitated into the stomach. There is little doubt that the best method for aspirating the jejunal and ileal contents is by means of the Miller-Abbott tube. When the bag can be gotten past the pylorus it descends into the lower intestine which threads itself on to the tube as each segment is collapsed.

One of the difficulties with the Miller-Abbott tube is getting the bag past the pylorus. It is often necessary to manipulate it under the fluoroscope and sometimes having the patient lie on the right side will be of aid. The administration of antispasmodics and water often help. The best routine consists in inserting the tube into the stomach (care being taken to prevent coiling, with the fluoroscope if necessary) and having it advanced one inch an hour. When it reaches the pylorus, a little water by mouth sometimes helps.

**Preparation of the Colon.**—The colon is no exception to the principles already discussed. Here, however, the bacterial content is extremely high and at times the material becomes inspissated and forms solid masses capable of producing mechanical effects, for this reason the preoperative preparation takes on additional significance. When the colon is able to evacuate itself, its contents will depend a good deal on the intake by mouth, for this reason, it is well to have the patient on a low residue diet and to restrict eating immediately prior to operation. The evening meal can be limited to liquids without milk and no food should be given thereafter until after operation. Such measures must be more drastic if obstruction exists. The Miller Abbott tube may prove helpful in the small intestine and thus prevent residual material from entering the colon or the tube may be allowed to descend to the obstruction permitting almost complete decompression. When such steps are necessary, some type of colostomy is usually required.

Cathartics in the presence of colonic obstruction are generally contraindicated. In a few cases with partial obstruction in which fecal material is actually getting through, small amounts of milk of magnesia will often be tolerated and will help to keep the material liquid. However, increasing obstruction does not demand increasing the cathartic. Generally, cathartics are contraindicated in the presence of obstruction. Although enemas are helpful in evacuating a more or less normal colon, they are of less value when there is interference of function.

Hence, enemas are of great importance in the routine preparation of surgical patients but are of secondary value if disease of the colon exists. Indeed, some surgeons order enemas rarely, except in the routine preoperative preparation. This, perhaps goes too far. If bowel function is diminished, an enema can be given the preceding night and the morning of operation. More than this is not necessary unless some impaction is present, a partial obstruction exists, or the patient is suffering from severe atony. Generally, an enema the night before or the morning of the operation is routine for operations on the upper part of the gastrointestinal tract.

Attempts to reduce the bacterial flora of the colon met with little real success until the sulfonamides became available. Now, there are several compounds that act in this way, the most effective being succinylsulfathiazole and phthalylsulfathiazole. These drugs reduce the coliform bacteria and the clostridia in the colonic contents. A high concentration of sulfathiazole in the blood is rarely produced and there are few toxic reactions unless the patient is particularly sensitive. A mild laxative action is brought about and the stools lose much of their odor. Most observers feel that preparation of the bowel in this way materially reduces the complications and tends to make stage operation unnecessary.

Succinylsulfathiazole or "sulfasuxidine" is probably the most popular of these drugs at present. Some recommend that it be given for one week preceding operation but in most instances it is felt that three, four or five days is enough for preoperative preparation. It proves effective in doses of 0.04 gm. per kilogram of body weight every four hours.<sup>3</sup> Another recommended method for determining the dosage is to give daily an amount equal to 0.5 gm. per kilogram of body weight, the initial dose being one half this amount, thereafter the daily amount is divided equally into six doses. The separate and daily dose with this latter method is higher than the former. There is a growing tendency to give smaller amounts, for example, 2 gm. every four hours. The bowels should move daily while the drug is being given, hence, enemas or colonic irrigations are at times indicated.

#### POSTOPERATIVE CARE

Immediately following operation the patient, of course, requires the closest nursing care which should be directed mainly by the post-operative orders. It is certainly a mistake to attempt a set of orders that will cover the entire hospital stay, however, specific orders for the next twelve hours should be written down.

**Intravenous Fluids**—At present, most patients having major gastrointestinal operations will be given fluids intravenously during the operation and it is often necessary to continue them afterward. The problem of fluid balance is sometimes complicated, to handle it prop-

erly the intake and output should be carefully charted. A special chart for this purpose is helpful (Fig 444). It will be seen that there is a space to enter the amounts administered or lost and when these are added together the total output can then be easily balanced against the intake. It is only by some such method that requirements can be anticipated especially in those instances in which there is an excessive

• Mr John Smith •				• 233 •				• MAY 5, 1945 •			
IN				OUT							
TIME	AMOUNT	TIME	AMOUNT	TIME	AMOUNT	TIME	AMOUNT				
7:5	80	8:00	40	7:30	13	8:2	200				
8:30	90	9:00	60	10:2	300	10	225				
9:45	60	9:4	40	12:45	250	3	150				
2:3	70	11	80		680		575				
1:00	40	3:3	90								
4:1	60	5:4	80								
6:45	60		390								
	460		460								
			150				1255				
9:1	2000	7:1	200		550		40				
			3000				460				
			3450				2215				

Fig 444 Method of charting intake and output of fluids

loss from the stomach or the bowel. The urinary output remains a reliable guide to adequate hydration. A patient having continuous gastric suction usually requires about 3000 cc intravenously every twenty-four hours. This is given as 2000 cc of 5 per cent dextrose and 1000 cc of 5 per cent dextrose in physiologic saline solution. Patients requiring infusions but not losing gastric juice can be given

1000 cc of saline solution every second day Coller<sup>4</sup> is probably right in believing that there has been a tendency to give too much sodium chloride. Blood chloride and carbon dioxide combining power determinations should be done if there is an excessive loss of gastric juice or fluid by diarrhea.

**Sedatives**—Morphine is still the best analgesic. Its advantages are better known than its disadvantages. The latter are taken up in the discussion on postoperative ileus and also under the prevention of complications. It is sufficient to state here that each case must be individualized according to the age, general condition, amount of pain and complications already existing. The same is true of the barbiturates, which are generally more efficacious as hypnotics but in addition allay apprehension and diminish the vomiting reflex.

**Postoperative Ileus**—Some degree of ileus occurs after almost all laparotomies. It may be mild persisting for a short time or it may be more prolonged, it may involve only a small percentage of the intestine or it may be more generalized. Treatment lies largely in eliminating the cause. Thus, minimizing trauma to the intestine (handling, exposure) will go far toward its prevention, and therapeutic efforts against bacterial peritonitis will shorten its duration. Of more interest in the present discussion is the prevention of distention, which itself delays or prohibits the return to normal function.

Wangensteen and his associates<sup>5, 6</sup> have shown that approximately 70 per cent of intestinal gasses consist of nitrogen, which can only be derived from the ingested air. The amount of air taken into the stomach during various operations has been measured and was found to be at times as much as 1000 cc.<sup>7</sup> Eating and drinking are also accompanied by swallowing significant amounts. Obviously, it is important to prevent these gasses from entering the intestine. This can largely be accomplished after operation if the patient abstains from taking anything by mouth. It is amazing how well most patients will get along under this regimen but it is also remarkable how difficult it is to carry this out. To be most effective, anything that will cause swallowing should be forbidden but it is hard to get full cooperation from the patient, his family and the nurses. Continuous gastric suction, which accomplishes the same thing by removing fluids from the stomach presents certain advantages. In the first place the patient may then take some liquids by mouth for they are removed by the tube. This makes him feel better. Then, too, suction removes the gastric and regurgitated duodenal contents which would descend into the intestinal tract or would be vomited. Once the material has gotten into the intestine, decompression is best carried out by the Miller-Abbott tube.

The place of drugs, enemas and diet in the treatment of postoperative or paralytic ileus poses questions on which there is no unanimity of opinion—and practices differ accordingly. Puestow<sup>8</sup> showed that

drugs which stimulate the small intestine have an inhibitory effect on the colon and that the converse is also true. The first problem, therefore is to determine which part of the intestine is to be stimulated. Neostigmine (prostigmine) is the drug of choice for its stimulatory action on the small intestine and pitressin is the best to bring about the same result in the colon. Morphine increases the muscular tone of the small intestine but, at the same time, diminishes the activity of the colon. There is evidence also that the dosage of the various drugs determines the mode of action on the intestinal tract.

There is a growing opinion that efforts should be directed toward remedying the cause of ileus rather than attempting to stimulate the intestine. Experience demonstrates the difficulty in obtaining function in the presence of active peritonitis and indeed it is doubtful that this would be to the patient's best interests. So it is too with the ileus that occurs from the trauma of laparotomy.

In the great majority of cases the intestine will function provided active peritonitis is not present, distention is controlled and the immediate effects of trauma have passed. We can do much to obviate these factors. Penicillin and the sulfonamides provide a powerful weapon against peritonitis and modern operative techniques are largely planned around a minimization of trauma. In addition, we have continuous gastric suction and the Miller-Abbott tube. The problem is well illustrated in patients with bacterial peritonitis. Here, some paralysis occurs but if the intestinal tract is not allowed to become distended while the infection is active, normal activity is resumed as soon as the process subsides. Such patients are treated from the beginning with continuous gastric suction or with the Miller-Abbott tube if there is already great intestinal dilatation. Little occasion will be found to use drugs if these measures are thoroughly carried out. The same may be said about cathartics and enemas.

The practical application of these measures may be summed up by stating that stimulating drugs, cathartics and enemas have little value in the treatment of ileus. Their main usefulness will be found in cases of the constipated patients confined to bed. After operation it often happens that the intestine regains function and the patient passes gas freely but there is a delay in the first bowel movement, when this happens, an enema or a mild cathartic will often bring about the desired result. Not infrequently, these measures will be required again but this is not peculiar to the postoperative period. It will be found that the same patient that requires repeated enemas or cathartics would have had to have them if put to bed when in his usual health.

In practice the state of the gastrointestinal tract is best evaluated from easily determined evidences of function. The persistence of tympanites obviously is indicative of a disproportion between the intake and output of the intestinal tract. Also the passage of flatus or

fecal material from the rectum means that propulsive force is present. Many physicians lay much stress on the auscultatory signs elicited over the abdomen as evidence of intestinal activity. These are frequently very helpful especially as an early indication of activity but, from a practical standpoint, nothing gives better evidence that the intestine can function effectively than the spontaneous passage of flatus or fecal material. If ileus is present, the physician should ask if anything has been passed from the rectum. An affirmative answer denotes that the patient can take liquids by mouth and if the ileus has been minimal, a soft diet can often be tolerated. As intestinal movements improve, the diet can be further expanded. There is no doubt that the patient recovering from paralytic ileus is more comfortable if the intake by mouth is restricted until it can be easily handled by the intestine. It is in this stage during which recovery is taking place that enemas or stimulating drugs will have most effect, but they are not frequently required because the intestine will then quickly regain its normal action unless distention with food and gas is produced by injudicious feeding. As mentioned before, an enema will sometimes be of aid in the first bowel movement.

**Diets**—Following operations on the stomach and duodenum the feedings should be carefully controlled. Most surgeons now prefer to leave in a tube and employ continuous suction, others only insert the tube once a day for the first few days to discover any accumulation while some employ these measures only when definitely indicated. All agree that little should be given by mouth at first and suction is indicated if there is stasis soon after operation. When suction is in progress water in small amounts is allowed for twenty four hours after which two ounces of water, tea or thin broth can be given every two hours. It is well at this stage to determine whether retention is occurring by comparing the intake with the output from the suction tube. If more is swallowed than comes back through the tube it is an indication that some of the fluid is passing. Another method is to clamp the tube for three and a half hours and then unclamp it for one half hour, this enables one to compare the amount taken in with that obtained by suction during the half hour period. This is perhaps a more exact method and will prove very useful. Once fluids go through the upper tract freely, the same liquids can be increased by 1 ounce for every two hour feeding each day, usually by the sixth day it is not necessary to limit the amounts allowed and a soft boiled egg morning and night will be well tolerated. The following day a feeding of cereal in the middle of the day is added, this schedule is continued until the ninth day, when a soft diet can be begun. There is little reason to make further changes until two weeks have elapsed from the time of operation. This regimen may be modified in many ways. In poorly nourished patients requiring proteins, egg white can



be given as soon as liquids are well tolerated, or amino acid preparations can be given by mouth. In the later periods also the diet can be changed to increase the calories and proteins without changing its bulk and consistency.

In the early management of these cases many surgeons merely continue uninterrupted gastric suction for forty-eight hours or longer and then determine whether liquids are tolerated. There is no objection to this provided the fluid and electrolyte balance is maintained. Since the patient is able to take little protein during this early period if hypoproteinemia exists, effort should be made to correct it as soon as possible by the administration of plasma transfusions and amino acids intravenously or orally.

Liquids occasionally fail to pass through the upper part of the gastrointestinal tract due to a nonfunctioning stoma. This situation sometimes persists for two weeks or more, being due to faulty technique or hypoproteinemia. Treatment consists in continuous suction and correction of the underlying cause when possible.

The management of the diet for patients having had operations on the small intestine is relatively simple. In a large measure one can be guided by the accompanying ileus. A tube in the stomach with continuous suction for the first two days at least is a good precaution if the operation has been of any magnitude. After that the intake by mouth is regulated by the ability of the intestine to handle the fluids and gasses as shown by the absence of distention, auscultatory phenomenon, and the movement of gas through the tract. At times, caution is justified in evaluating the latter because the colon may begin its motor function before the affected segment of small intestine. Usually, however, not much time elapses between these two events if no mechanical obstruction is present.

Much the same can be said regarding management of the patient having had an operation on the colon. Here again, the object is to keep the intestinal tract proximal to the involved area deflated until fecal material can pass that point. It is well to begin with at least twenty-four hours of gastric suction, a longer period is usually required. A safe plan is to continue this until the gas is expelled from the rectum, then give water, tea and broth. If this is well tolerated the diet is expanded but milk is forbidden until the patient is well established on a soft diet. A soft diet should never be given before the fifth day and it is usually better to delay longer if there is any doubt as to how it will be tolerated. Each case must be individualized and it will be found that hunger, the absence of distention and the passage of gas from the rectum will prove the most reliable guides to management. Generally, cathartics are to be avoided but when it has been demonstrated that intestinal contents are passing small amounts of mineral oil are helpful in preventing impactions.

**Prevention of Complications**—It has been long recognized that following laparotomy the patient generally tends to lie on his back and deep breathing and coughing are largely avoided particularly after operations on the upper part of the abdomen. Atelectasis and pneumonia are related to the diminished respiratory excursions, hence anything which will correct this will lessen the incidence of pulmonary complications. Forced voluntary coughing will bring up retained bronchial secretions, thus decreasing the chances for atelectasis. It is for these reasons that all patients following laparotomy should be made to turn frequently and take deep forced respiration, especially during the first few days following operation. Coughing is insisted upon if there is any abnormal secretion. Large doses of morphine are avoided especially in the aged because it diminishes the respiratory rate and the cough reflex. Of importance also are preventive measures against thrombosis and embolism. These consist chiefly of adequate hydration, movement of the body and legs, and the avoidance of Fowler's position.

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## PREOPERATIVE AND POSTOPERATIVE CARE OF PATIENTS WITH THYROID DISEASE

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THE greatest cause of a high operative mortality rate in patients suffering from thyroid disease may be attributed to errors in (1) pre operative preparation, (2) choice of time for operation and (3) post operative care. The management of these patients as individuals is probably more important than in most other conditions. Such patients often present therapeutic problems and should be entrusted only to those capable of rendering competent treatment. The internist and surgeon should cooperate in the preparation of the patient for operation, but the final decision as to time and extent of surgical intervention should be left to the surgeon's judgment.

### PREOPERATIVE PREPARATION

A careful history should be elicited, with particular attention focused on associated pathologic conditions such as diabetes, early signs of congestive heart failure, angina pectoris, coronary occlusion, renal damage and tuberculosis. It is of utmost importance that these conditions be recognized early and treated effectively. Likewise, a careful and complete physical examination should be done. The size of the thyroid gland and its consistency, and the mobility or fixation of surrounding tissue should be noted and carefully followed during the preoperative management.

A roentgenogram of the chest should be made routinely on patients with medium sized or large goiters. The film will show an intrathoracic mass when present and might make one suspicious of a malignancy. It will demonstrate a substernal or retroclavicular gland and also show the position of the trachea. Deviation of the trachea or even the larynx from the midline is of importance. The cardiac shadow will also be shown. The severity of the disease and coexisting pathologic conditions are most important factors in planning the extent of the operation. The size and position of the gland are also important because of the possible technical difficulties to be met at the time of operation.

Laryngeal examination of the vocal cords should be done routinely.

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both before and after operation. It is definitely indicated in all cases of suspected or proved malignancy of the thyroid gland.

The modern management of thyrotoxicosis is frequently dependent upon certain laboratory methods which alone reveal some of the associated conditions. The degree of impaired hepatic function, as indicated by the hippuric acid test, has been found to be almost invariably in direct relationship to the severity of hyperthyroidism as determined by the basal metabolic rate and the clinical estimate of the patient. The galactose tolerance test is of definite aid in confirming the diagnosis of hyperthyroidism as well as in supplying suggestive evidence of hepatic damage in borderline cases. The cephalin cholesterol flocculation test may be of value in determining the extent of hepatic disease. Determinations of the icterus index and serum bilirubin are at times valuable in indicating the degree or even in revealing unsuspected existence of hepatic damage which occurs as a sequel to hyperthyroidism. There is reciprocal relationship between the average elevation of the basal metabolic rate and the average lowering of the blood cholesterol level. Blood iodine determination may furnish important information concerning the approximate time for and the extent of operation and may suggest which cases are most likely to recur. The basal metabolic rate is perhaps one of the most useful laboratory aids in determining progress in hyperthyroidism as well as the time for operation. Although the basal metabolic rate is a valuable laboratory aid, it is reliable only when it corresponds to the clinical findings. Too much confidence cannot be placed in any one test, nor can a test replace clinical experience or diagnostic ability. The responsibility for decisions as to the course of therapy depends not on the results of the test per se but on the judgment of the physician.

The preoperative preparation of patients with goiter includes rest, the administration of sedatives, iodine or thiouracil or both, estrogenic substances, calcium, adequate diet, fluids, vitamins and transfusions, survey of cardiac status, including an electrocardiogram, complete blood count, protein determinations with albumin globulin ratio, routine urinalysis, and repeated basal metabolic determinations.

**Rest**—The rest must be both physical and mental. The severely toxic patient must be hospitalized for the preoperative preparation, whereas the patient with mild toxicity may be ambulatory during this period. The room should be quiet and comfortable. Air conditioning may be advantageously employed to insure rest. Visitors must be few and carefully selected. Since few nervous patients bear isolation well, some well chosen visitors should be allowed. The visit should be terminated before the patient becomes irritated or exhausted. Mental rest is important. It should be remembered that a psychosis may develop in these patients. Apprehension and emotional instability are some of the most difficult conditions to obviate. However, rest in bed with kind

treatment will soon allay apprehension and usually in a few days these patients present an entirely different appearance. As soon as the patient shows improvement, he may be allowed to sit in a chair part of each morning and afternoon. This not only encourages the patient but also shows him how much has been accomplished. A few steps about the room will be sufficient exercise to prevent severe muscular atrophy. Patients who are in a crisis or impending crisis or have cardiac decompensation must be confined to absolute rest in bed until these have been corrected. All discussions within hearing distance of the patient should be confined to remarks of encouragement. A responsible relative should be informed of the exact day of his operation, and the patient should be told the operation will be done as soon as *his condition improves sufficiently to permit its being safely performed*.

**Sedation**—The patient must be urged to spend from eight to ten hours in bed at night and to take daily afternoon naps for two or three hours. Thyrotoxic patients will invariably need help in obtaining sufficient sleep. The routine administration of one of the less harmful sedatives such as bromide, phenobarbital and allied compounds is indicated. The dosage of these drugs depends upon the toxicity of the patient. Sodium bromide is probably the sedative of choice and should be administered three to four times a day in doses of 15 to 20 grains. The bromide acts as a psychic sedative and should produce better results than the barbiturates, as they are cerebral sedatives. Persons who have received bromide for a considerable period prior to thyroidectomy should, as a safe precaution, have blood and urine determinations because of similarity of the symptoms of hyperthyroidism and chronic bromide poisoning. An accumulative effect is likely to follow the extensive use, over a considerable length of time of members of the barbital group. On the other hand, barbiturates are suitable for intravenous administration and may serve a very useful purpose in the control of severe excitation. Drugs such as chloralhydrate and chlorobutanol which have a deleterious effect on the liver, especially when it has already been damaged as a result of hyperthyroidism are to be avoided.

**Iodine**—In the preparation of these patients for operation it is universally admitted that iodine finds its greatest usefulness. Since the introduction of its use by Plummer, many cases previously considered inoperable have been able to receive the benefits of operation. Iodine is generally prescribed in the form of Lugol's solution in dosage of from 10 to 30 drops three times daily. This is in excess of the organic iodine the thyroid can utilize from a theoretical standpoint. However clinically these amounts are often required. The maximum response usually is obtained from the tenth to the fourteenth day, but there is great individual variation. Iodine should not be given except in

preparation for operation There is a period of maximum benefit following iodine therapy and if the administration is prolonged beyond this point, its therapeutic effect is rapidly lost and a return of the symptoms is observed For this reason, it is particularly desirable to limit its uses to preoperative care Patients receiving iodine continuously may become refractory to the drug and offer difficult therapeutic problems

**Thiouracil**—Thiouracil is also of value in the preoperative care of some cases of thyrotoxicosis According to Astwood<sup>1</sup> and others, thiouracil inhibits synthesis of the thyroid hormone and also increases hyperplasia in a patient suffering from hyperthyroidism It, therefore, produces a hyperplastic nonfunctioning goiter, whereas iodine, in contrast, reverses the disease anatomically by inducing involution Therefore, as suggested by Moore and his associates,<sup>2</sup> there is a rational basis for combining the two drugs in the preoperative management of thyrotoxicosis We believe thiouracil has a definite place in the preoperative management of the severely toxic and the iodine-fast patient It possesses the disadvantages of producing toxicity occasionally and requiring a much longer interval to reduce thyroid toxicity It has been our experience that the hyperplasia is accompanied by increased vascularity and friability of the gland, which greatly increases the technical difficulties at operation A toxic patient who has been receiving iodine for a long time has a greater storage of colloid in the thyroid gland and will respond to thiouracil much more slowly than a patient who has not taken iodine These patients must be hospitalized The blood picture and the clinical condition must be followed carefully in order to avoid complications Our experience with it as a preoperative measure has been limited to a few cases Thiouracil (0.2 gm) was administered to these patients three times daily until a definite response has been obtained The dosage was then reduced to 0.2 gm twice daily until about ten days or two weeks before operation, then further reduced to 0.2 gm daily until the day of operation Iodine in doses of 10 drops three times daily was administered for the last ten days or two weeks before operation The results from this therapy have been very gratifying and the postoperative convalescence has been smooth and uneventful We have encountered no severe complications

**Estrogens**—The estrogenic substances are of value in the preoperative management of thyrotoxicosis The rationale for the administration of estrogen is based upon the fact that it inhibits elaboration of the thyrotropic hormone of the anterior pituitary gland Storck and Holcombe<sup>3</sup> have shown that patients placed on our regular preoperative regimen without iodine, until the pulse rate reaches a plateau or becomes approximately stationary, will show a lowering in pulse and basal metabolic rates by the administration of estrogenic substances

alone Continued administration of estrogenic substances without iodine showed a rise in rates, this suggests that refractoriness may occur if administered over too long a period

In a group of patients whose basal metabolic rate averaged plus 47.7 (one fourth of whom were iodine fast at the time of admission) it was shown that the peak pulse rate on the first postoperative day in the estrogen treated group was lower than was the average pulse rate in a similar control group.<sup>4</sup> The administration of estrogenic substances is warranted in the severe cases of hyperthyroidism and in the iodine fast cases. We give 1 mg of stilbesterol three times daily for a period of five to eight days before operation.

**Calcium**—Thyrotoxicosis is associated with a great increase in calcium excretion and there is evidence that a deficiency of calcium may play a part in hyperthyroidism. We believe that the administration of calcium should be included in the preoperative preparation of the hyperthyroid patient. Calcium gluconate or lactate is an excellent form in which it can be administered. However, adequate amounts of vitamin D should be given to insure proper utilization of the calcium.

**Diet**—The diet should include large amounts of carbohydrates and proteins. Patients with hyperthyroidism because of increased metabolism frequently burn liver glycogen which becomes replaced by fat. The carbohydrates in the diet restore liver glycogen, which results in the loss of abnormal fat within the liver. Proteins aid in the storage of glycogen in the liver and must be present in quantities sufficient to

nutritional balance be restored to normal and a gain in weight obtained. In the occasional patient who cannot eat the intravenous administration of glucose and amino acids will supplant the oral intake and increase the caloric consumption. Obviously tea, coffee and alcoholic beverages should never be allowed. Smoking should not be permitted because it produces a chronic irritation resulting in bronchorrhea which predisposes to atelectasis. We insist that all patients refrain from smoking for two weeks before operation. Fats may be given in small amounts. However, excessive amounts are undesirable as they tend to produce gastrointestinal disturbances and diarrhea.

**Fluid Intake**—The total fluid intake should be large enough to insure a urinary output of 1000 to 1500 cc every twenty four hours. The fluid intake of patients with congestive heart failure must be adjusted accordingly until cardiac compensation has been restored. Transfusions of whole blood or plasma are administered according to the

blood count, serum protein determinations and the albumin globulin ratio

**Cardiac Therapy**—Auricular fibrillation is the most frequent type of cardiac arrhythmia encountered. It is present in practically all cases of congestive failure and in many that show no evidence of failure. This should be corrected with the cooperation of the internist. The present trend is away from quinidine therapy preoperatively in patients who do not regain normal rhythm because postoperatively in almost all of them fibrillation will occur with quinidine.

**Vitamins**—Thiamine chloride aids in oxygenization of the cells, increases the tonicity of the intestines and stimulates the appetite. It is our routine to give 5 to 10 mg. three times daily. The need for vitamin K in the preparation of the patient with hyperthyroidism accompanied by jaundice has been demonstrated. Prothrombin determination should be made and vitamin K administered if indicated.

**Preanesthetic Medication**—The immediate preoperative medication is important in allaying apprehension and making smooth anesthesia possible. The night before operation, phenobarbital,  $1\frac{1}{2}$  grains, or pentobarbital sodium (nembutal),  $1\frac{1}{2}$  grains, should be administered. Morphine,  $\frac{1}{4}$  grain, with scopolamine  $\frac{1}{150}$  grain, should be given forty-five minutes before operation. The advantage of scopolamine over atropine as a preanesthetic drug is that scopolamine causes less inspissation of bronchial secretion and is more effective because it acts synergistically with morphine in depressing the cerebral cortex. It produces a more profound amnesia and tends to counteract the depressing effect of morphine upon the respiratory center.

#### TIME OF OPERATION

The decision as to the proper time for operation is extremely important in the treatment of severe thyrotoxicosis. It can generally be made with a careful evaluation of changes in weight, pulse rate, basal metabolic rate, freedom from complications such as jaundice, diarrhea, anorexia, vomiting, other conditions such as diabetes, and the general appearance of the patient. The history of a previous psychosis and the immediate condition of the cardiorenal and hepatic systems must be considered. Except in mildly toxic stages, a gain in weight is extremely desirable and usually possible. A resting pulse rate of 110 or below may be considered safe. The basal metabolic rate which should become progressively lower or stationary and preferably below 50, may be misleading as to the degree of toxicity and should serve only as an adjunct to the clinical findings. However, if it does not correspond to the clinical findings, the test should be repeated. In the final analysis clinical judgment is necessary to determine when the patient is ready for operation.

Because of the psychic factor in hyperthyroidism we are convinced



that the goiter should be "stolen" (as suggested by Crile), and for this reason the patient is not told when he is to be operated upon. On routine rounds, the night before the contemplated operation the intern is instructed in the presence of the patient to draw blood for blood chemistry and if the results are satisfactory the operation can be done in several days. The morning of the operation the intern appears in his usual uniform (not in his operating clothes) and inserts a needle into the vein supposedly to secure a sample of blood but instead injects enough sodium pentothal to produce narcosis. At the same time the anesthetist is outside the room and, as soon as the patient is asleep, takes charge of the case. The patient is taken immediately to the operating room and given an inhalation anesthetic. When he awakens his thyroid has been removed.

### POSTOPERATIVE CARE

The postoperative therapy begins as soon as the incision has been closed. A snug compression bandage of machinist's waste should be applied evenly to exert slight pressure over all areas which have been undermined or exposed, and this should be held in place with adhesive tape. This type of bandage aids in supporting and securing immobilization which adds to the patient's comfort. The anesthetist should see the patient safely into bed and make certain the airways are free from obstruction. If there is any doubt, he should remain until breathing has become comfortable and easy. Morphine is the most valuable drug for the control of discomfort and restlessness during convalescence from thyroidectomy,  $\frac{3}{4}$  grain should be administered as indicated, depending upon the patient's age, weight and degree of toxicity. Sedatives should be given in large enough quantities to insure an adequate amount of sleep. Sodium luminal (2 grains) should be given for restlessness, nausea or insomnia. The patient should be placed in the prone position until he has reacted from the anesthetic and then should be placed on a low back rest.

**Fluids and Vitamins**—Fluids which were administered during the operation (e<sup>operatively</sup> and post<sup>operatively</sup>) thousand to

the first twenty-four hours postoperatively depending upon the severity of the thyrotoxicosis. In the severely toxic patient 1 gm. of potassium iodine or 30 to 40 minims of Lugol's solution should be introduced in the first infusion bottle. Five hundred milligrams of vitamin C and 50 mg. of vitamin B<sub>1</sub> should be included in the second bottle of glucose. The exact amount of fluids administered should depend upon the degree of toxicity, the size and age of the patient and associated conditions such as cardiac decompensation. A deficiency in

vitamin C will interfere with collagen formation and delay wound healing

**Oxygen**—The temperature, blood pressure and pulse should be recorded every thirty minutes for the first three to six hours. All toxic patients should be given oxygen for the first twelve hours postoperatively. We usually administer oxygen through the Lombard mask which though not extremely efficient, is comfortable to the patient. Oxygen may be administered by the nasal catheter, BLB mask or tent. An advantage of the tent is that it can be refrigerated. However, it has been our experience that most patients do not like a tent and we seldom find it necessary to utilize refrigerated oxygen. An air conditioned room would be a valuable adjunct to help control excessive body temperature.

Patients are instructed to take at least ten deep breaths every hour and three to five deep coughs every two hours to prevent atelectasis and pneumonia. Tea without sugar or cream, tap water and fat free broth are allowed after nausea has ceased.

**Steam Inhalation**—We routinely advise steam inhalations containing one drachm of compound tincture of benzoin. The warm moist steam with benzoin vapor lessens the tenacity of the mucus and renders it more liquid, this facilitates coughing and expectoration. Usually the steam inhaler is turned off after thirty or forty minutes and the patient allowed to rest for one, two or three hours according to the individual need.

**Control of Nausea and Vomiting**—In recent years we have noted that nausea and vomiting seldom occur. Occasionally, a patient will vomit once or twice during the first twelve or fifteen hours postoperatively. This is frequently due to the anesthetic or a sensitivity to morphine and is readily controlled by injecting sodium luminal, hypodermically, allowing nothing by mouth except water or chips of ice to relieve the sensation of thirst, and administering intravenous fluids.

**Nursing Care**—Nothing will replace good nursing care. A tactful nurse can do a great deal to allay nervous tension and fear. An effort should be made to secure a room in the quietest part of the hospital. All noises within hearing distance of the patient's room should be prohibited whenever possible. No visitors should be allowed until the postoperative reaction has subsided.

The residual postoperative convalescence is usually uneventful and unless complications develop the patient may go home on the third to the seventh postoperative day. Of course, this depends upon the degree of toxicity present at the time of operation.

**Postoperative Complications**—It is of utmost importance to recognize postoperative complications early and treat them adequately. The extent of postoperative care must obviously vary with the condition of each individual patient. Nevertheless it is imperative that a con-

stant vigil by a competent and experienced nurse be maintained during the first twenty-four hours. The nurse should report any change in the patient's respiration, pulse, color or temperature.

A disturbing and rare complication is the occurrence of *thyroid crisis*, "*thyroid reaction*," "*postoperative toxemia*," or "*thyroid storm*." This usually develops during the first twenty-four to thirty-six hours following the operation. These reactions are usually due to inadequate preoperative preparation, incorrect time selected for operation or error in the judgment of the intensity of the hyperthyroidism, all of which can be obviated. This complication is characterized by extremely rapid pulse, fever, pronounced excitability and even delirium at times. The patients usually are restless, noncooperative, mentally alert to everything that is going on and, as a rule, exceedingly fearful of the outcome of their condition. The treatment consists of the administration of large doses of narcotics in the form of morphine and barbital as indicated, intravenous injection of sodium iodine, oxygen therapy, and the use of an air conditioned room if possible. Hyperpyrexia must be controlled by utilizing fans, iced towels or bags. The ice bags should be placed over the temporal, brachial, radial and femoral vessels. The cooling effect in these regions is most effective for obvious anatomic reasons. The fluid intake must be increased up to 5000 cc a day depending upon the patient's body temperature and the urinary output. As a rule, ingestion of fluids by mouth is seldom possible. In the patient with severe cardiac decompensation the fluid intake must be curtailed to 2000 cc or less depending upon the individual needs. We have not seen a real postoperative "thyroid storm" for several years.

*Injury of the recurrent laryngeal nerve* has always been one of the feared complications of thyroidectomy. We insist that every patient have a routine laryngeal examination preoperatively and postoperatively to detect recurrent laryngeal paralysis if present. Ordinarily, the loss of function of one cord results in temporary loss of the voice which may last from a few days to several months. Respiration is little if any affected. The patient can be assured that the voice will return, because the cord will eventually come to the midline and there will be enough tension to obtain a fairly good voice although hoarseness may persist. The treatment of unilateral injury of the vocal cord therefore, resolves itself into reassuring or comforting the patient. Bilateral vocal cord paralysis is a catastrophe which may cause immediate and serious laryngeal obstruction with obvious inspiratory stridor and is an indication for immediate tracheotomy. The incision in the trachea should be placed low through the second ring of the trachea so that cicatricial stenosis will not further complicate the laryngeal obstruction. For those patients who are not willing to wear a tube submucous resection<sup>6</sup> of the vocal cords should be done. If the paral

ysis is due to pressure or edema or mild trauma, the tracheotomy tube can usually be removed within a few weeks. King<sup>7</sup> described a procedure which consisted of transplanting the omohyoid muscle to the base of the arytenoid cartilage and reconstructing the larynx, thus widening the aperture between the cords. Attempt at suture of the severed laryngeal nerves is justified and, if done, should be within three months.

*Postoperative hemorrhage* is always preventable but when it occurs is probably one of the most distressing complications. The hemorrhage may be of two types. It may arise from a large artery, resulting in sudden swelling of the neck, rapid development of dyspnea and cyanosis, or it may originate in a small vein or capillary ooze which may cause only respiratory difficulty. Either of these can collapse the trachea. If the tracheal wall has been thinned by long continuous pressure of a large, hard goiter, collapse of the trachea is favored with resulting dyspnea and possible complete obstruction. If hemorrhage develops, it usually manifests itself from the first to the tenth hour following the operation. Symptoms of respiratory stridor demand immediate inspection of the wound with evacuation of the clot and tracheotomy if necessary. If cyanosis remains after evacuation of the clot, tracheotomy is imperative.

Another most undesirable postoperative complication is *parathyroid tetany*. This complication is produced by the removal, injury or vascular deprivation of the parathyroids. It usually appears within the first twenty-four hours after operation but may not develop until two to three weeks later. When it develops late, it is probably due to marked fibrosis resulting from excessive trauma at the time of operation. The earliest symptoms are tingling of the hands and feet and sometimes a drawing sensation about the mouth and nose. Carpopedal spasm (Trousseau's sign) may be present and is produced by constricting the arms above the elbow. The early manifestations consist of restlessness, tachycardia, irritability, and muscular twitchings, especially of the upper extremity. Parathyroid extract (parathormone) should be given in all severe cases and particularly the acute ones. The parathyroid extract exerts its maximum effect in four to six hours after muscular injection. Calcium gluconate should be given intravenously. Large doses of vitamin D and the calcium should also be given by mouth. Oral use of dihydrotachysterol (A.T. 10) and calcium as outlined by MacBryde<sup>8</sup> and others has been effective. This regimen controls most cases satisfactorily.

*Pulmonary complications* are exceedingly rare and usually occur in the form of atelectasis within the first twenty-four to forty-eight hours. The condition is usually ushered in with a rapid pulse, rise in temperature to 103° to 105° F, and signs of dyspnea and apprehension. There may or may not be pain on the affected side of the chest.

The treatment consists of removing the obstruction in the bronchus which is usually inspissated mucus. The patient should be turned on the unaffected side and made to take deep breaths and cough violently. This will usually result in expectoration of a thick plug of mucus followed by prompt subsidence of symptoms. If this fails, a catheter connected to a motor suction apparatus can be introduced through the nose into the trachea and, by a combination of tracheal irritation and aspiration, the obstruction can be removed. If these two measures are ineffectual, a bronchoscopic examination of the bronchial tree and aspiration under direct vision are indicated. Recurrent attacks of atelectasis may be prevented by changing the position of the patient often and encouraging deep breathing and coughing at least once each hour.

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## COMPLICATIONS FOLLOWING OPERATIONS ON THE GASTROINTESTINAL TRACT

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ALTHOUGH complete freedom from postoperative complications cannot be achieved, many can be avoided by proper preoperative preparation of the patient, by careful operative technic, and by the institution of proper postoperative care. Following operations on the gastrointestinal tract many complications may ensue. If pulmonary and vascular complications are left out of consideration for the moment, others directly attributable to the operative field or the nature of the structures involved remain.

### WOUND INFECTION

One of the most frequent complications is infection of the abdominal wound. This may be inevitable as in drainage of intra-abdominal abscesses, but in many other instances may be accidental or partially avoidable. Some of the factors which are of value in preventing infection of the abdominal incision are as follows: careful cleansing of the skin, covering of the skin up to the incision so as to avoid surface contamination, and avoidance of undue trauma to the tissues of the abdominal wall. In this clinic it is almost routine procedure to fasten towels to the skin edges with Michel skin clips as soon as the incision has been made. In long procedures, and especially in those in which hollow viscera are opened, the wound itself should be protected by pad or other covering laid over the edges. After closure of the peritoneum, it is routine procedure at this clinic to flush the wound gently but thoroughly with normal saline at body temperature. The amount of fat and bits of debris that are removed mechanically by this method is at times astonishing, and I am firmly convinced that wounds heal more kindly after such irrigation.

If infection should develop, it can in most instances be controlled by opening the incision widely so as to get free drainage, followed by irrigation or the use of compresses, or both. Chemotherapy, which is better given by general administration rather than by local implantation, may be of value in infections of the wound, but is rarely indicated unless other infectious complications are also present.

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## DISRUPTION OF THE WOUND

When a surgeon closes an abdominal incision he expects it to heal but experience has shown that even with the greatest care a small percentage of wounds fail to do so, and disruption of the wound may develop. This complication usually occurs about the fifth to ninth day after operation, often in patients who have had more or less distention or who have not had a smooth postoperative course. Not infrequently the first sign is a serosanguineous discharge from the wound and when there is drainage in a wound previously dry, disruption should be thought of and looked for. Those who have studied this problem disagree as to the cause of disruption, though many factors seem to be involved. Anemia, low plasma protein levels, imperfect closure of the wound, unusual strain such as that produced by severe and frequent coughing, infection, and lack of sufficient vitamin C are some of the more important causes. At this clinic, wounds which have broken open are closed with through-and-through wire sutures, according to the technic described by Reid, Zinninger and Merrell.<sup>1</sup> This may be done under general or local anesthesia. The viscera are held back by a laparotomy pad, the peritoneum is grasped with clamps, and adherent bowel or omentum is freed by blunt or sharp dissection from the peritoneal surface for about 1 inch from the edges of the incision. Wire sutures on a large, hand sewing needle with a cutting edge are then passed through the entire thickness of the abdominal wall and after all are placed they are pulled up individually and twisted. In an attempt to prevent disruption of potentially infected wounds, it is more or less routine procedure here to close the abdominal wall with through-and-through wire sutures following such procedures as closure of perforated hollow viscera, and other operations in which actual or probable contamination of the edges of the wound has occurred.

## PERITONITIS

Peritonitis is a much feared postoperative complication, for it is often difficult to control and may be fatal. It is usually evidenced by fever, leukocytosis, prostration, abdominal distention and vomiting. The distention and vomiting are usually due to ileus which almost constantly accompanies or follows peritonitis. When one listens to the abdomen with a stethoscope, peristaltic sounds are absent or markedly diminished. If x rays are taken, general gaseous distention is seen, often with evidence of exudate between adjacent loops of bowel as shown by separation of the loops (see Fig. 445).

Treatment of peritonitis consists of placing the intestinal tract at rest and reducing distention by continuous suction drainage with a tube in the stomach or duodenum, supportive treatment such as blood and plasma transfusions, maintenance of proper fluid and electrolyte

balance, and chemotherapy. The patient must be examined frequently to avoid overlooking the development of an intra abdominal abscess. Continuous gastric suction by Wangenstein's method has contributed greatly to increasing the patient's comfort and reducing mortality. It is desirable that all fluid obtained by suction be collected in a separate bottle and the amount and character charted. The amount collected each twenty-four hours should be replaced by an equivalent amount of normal saline parenterally. Enough additional fluid should be given to supply at least 2000 cc of fluid over and above that removed by suction. This may be blood, plasma, or glucose solution in distilled

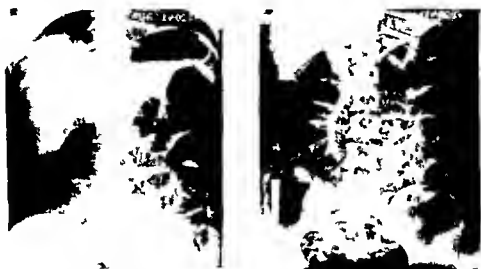


Fig 445—Ileus with peritonitis. Roentgenograms in erect and recumbent positions. Generalized gaseous distention with separation of distended loops of bowels probably due to fluid or pus.

water. Frequent determinations of blood plasma chlorides, blood plasma proteins and carbon dioxide combining power should be made to serve as a guide for maintenance of approximately normal levels. The blood chlorides should be 450 to 500 mg per 100 cc, blood proteins in excess of 6 mg per liter, and carbon dioxide combining power around 65 volumes per cent.

The value of chemotherapy in the treatment of peritonitis still remains to be estimated accurately. There is considerable evidence that it is of value if used early in the course of the disease. Parenteral administration is imperative since the patient can be given nothing by mouth. Sulfadiazine can be given 4 gm at a time as an intravenous or a subcutaneous injection. This dosage ordinarily can be repeated once each twenty to twenty four hours, or the amount may be divided with an original injection of 4 gm followed by 2 to 3 gm every twelve to eighteen hours. The precautions necessary to avoid toxic



reaction should be observed. There is also difference of opinion regarding the value of penicillin in peritonitis but preliminary studies indicate that it may be of value. It may be satisfactorily administered in a dosage of 15,000 to 20,000 units intramuscularly every three hours. Signs of improvement are lowering of temperature, general improvement in appearance, reduction of abdominal distention, reappearance of peristalsis, and reduction in volume of return through the suction tube.

#### INTRA ABDOMINAL ABSCESES

General improvement may occur but fever and leukocytosis may continue. In such an event, one should think of the possibility of development of an intra-abdominal abscess. The commonest sites are in the pelvis, in the flanks and in the subphrenic spaces. Abscesses in the free peritoneal cavity may often be palpated as immovable masses—characteristically not particularly tender. Pelvic abscess can usually be felt only on vaginal or rectal examination. Subphrenic abscess is the most obscure of all, and may present few physical signs. Fullness of one side of the thorax with diminished excursions of the costal margin, and tenderness when the thorax is compressed are signs often present. Elevation of the diaphragm with limitation of motion may be demonstrated by careful percussion of the back, or recognized more certainly by fluoroscopy or x-ray. Sometimes an air bubble with fluid level can be seen in an abscess. On the left side, accurate diagnosis of subphrenic abscess is facilitated by giving the patient a small amount of thin barium by mouth and then examining the patient in Trendelenburg position as described by Carter.<sup>2</sup> If there is a filling defect between the upper margin of the stomach and the diaphragm, one may assume that it is due to a subphrenic abscess. Once the diagnosis is established, the abscess should be drained by a suitable method.

#### INTESTINAL OBSTRUCTION

Ileus occurring without peritonitis, while usually not serious, is distressing both to the patient and the physician. Since its etiology is obscure, measures to prevent its development cannot be stated clearly and specifically. Rough manipulation of the bowel, especially traction on the mesentery, prolonged cooling or drying of the bowel from undue exposure outside the peritoneal cavity are factors which may predispose to ileus. On the other hand it may develop following the most simple procedures. When ileus occurs the abdomen becomes tightly distended, peristaltic activity is diminished or absent, the patient vomits dark green fluid, but is unable to expel gas per rectum and often is unable to void as well. Many surgeons now believe that this complication can be avoided by getting patients out of bed almost immediately after operation and therefore have their patients get out of bed the

first or second day after operation. A number of publications have appeared recently,<sup>3</sup> strongly urging such a method, and most surgeons who have tried it seem to be quite enthusiastic about it. At this clinic, management so far as getting patients out of bed is concerned follows old conservative methods which have worked so well in the past. Another method widely used for the prevention of ileus is the routine administration of one of the drugs which stimulate the sympathetic nervous system, such as pituitrin, pitressin, prostigmine and doryl. At this clinic, we have not been impressed by the value or need of such drugs. They are never used routinely, but only in isolated cases.

When ileus does develop in the absence of definite evidence of peritonitis, the most important aid in treatment is deflation of the gastrointestinal tract. This is accomplished by the use of continuous suction



Fig 446—Intestinal obstruction. Roentgenograms in erect and recumbent positions, showing distended loops of small bowel, with no intervening fluid and areas without gaseous distention.

drainage with a simple Levine tube in the stomach or duodenum, or a Miller-Abbott tube in the ileum. Repeated enemas also are helpful, and pituitrin, pitressin or prostigmine may be given at the time of the enema. Parenteral feedings must be given during this period for nothing can be absorbed by mouth.

Mechanical obstruction occurs every now and then as a postoperative complication. It is frequently unrecognized and on the whole is badly treated, the surgeon being unwilling to make a positive diagnosis or to reopen an abdomen shortly after a preceding operation. Often the vomiting and pain are considered part of a stormy postoperative course, and at other times the true picture is obscured by continuous suction drainage. The most important diagnostic features are the association of pain with audible peristaltic rushes, persistent vom-

ing or return of large quantities of fluid through the suction tube and the roentgenologic appearance of the abdomen. In contrast to the uniform gaseous distention seen in paralytic ileus there is characteristically seen distention of some of the intestine but other areas are devoid of gas due to the presence of collapsed loops of bowel (Fig 446). However it is important to reemphasize that the most important signs are the cramplike pains synchronous with audible peristaltic rushes. Adhesion of a loop of bowel to part of the recent operative field is the most common cause of postoperative obstruction though other things such as volvulus or protrusion of a loop of bowel through a newly made and incompletely closed opening may also occur. Since adhesion to suture lines or denuded areas is the most frequent cause it is important in the operative procedure to reduce the likelihood of adhesions as far as possible by careful reperitonealization of denuded areas, accurate suture of the peritoneum during closure and if possible interposition of omentum between bowel and suture lines. Also in placing drains it is important to try to make one side of the drainage tract a fixed structure such as parietal peritoneum or undersurface of liver, and not to bring out any drain which is surrounded on all sides by loops of small intestine.

Once the diagnosis of intestinal obstruction has been made, operation should be performed promptly because obstruction of this sort seldom improves under conservative management and the patient is often already depleted to some extent by the previous operation. It is best to explore through the previous incision if it is uninfected since the obstruction is usually in the recent operative field which can be reached most directly through the original working incision. Ordinarily the obstruction can be easily found and released. At this time the wound following such a procedure is closed with through and through wire sutures.

#### URINARY RETENTION

Urinary retention of greater or lesser degree is not infrequent following abdominal operations. At times it is very persistent and is not relieved until the patient gets out of bed. Advocates of getting patients out of bed a day or two after operation point out that with this method of management urinary retention is rarely seen. Often it is only temporary and is gone once the patient has learned to relax the vesical sphincter and void while lying in bed. In managing patients who have difficulty in voiding sedatives that relax the tone of the nervous system such as belladonna and its derivatives are often of help. Pouring warm water over the perineum at times allows the patient to void. If these measures fail the patient may be allowed to sit on the edge of the bed or even stand up. An ampule of doryl hypodermically may make the patient void. If there is no contraindica-

ion to giving an enema, it might be tried—water and glycerine, 3 ounces of each, makes a satisfactory enema for this purpose. As the enema is expelled the patient often voids more or less involuntarily.

If all these measures fail the catheter must be used. There is no real objection to catheterization and it is better to resort to it promptly than to persist with other measures until the bladder becomes over-distended. If overdistention of the bladder is not recognized promptly, the bladder wall is liable to lose its tone and it may take some time for this to be regained, during which time the patient may void apparently satisfactorily but really with incomplete emptying of the bladder. Therefore, once such overdistention has occurred, it is usually wise not only to catheterize once, but to repeat the catheterization every eight hours until normal voiding returns. It is often found that this can be attained more rapidly if after catheterization  $\frac{1}{2}$  to 1 ounce of 0.5 per cent aqueous solution of mercurochrome is instilled into the bladder. In some instances the operative field impinges on the bladder or its nerve supply, and in these cases a retention catheter is generally placed in the bladder at operation, e.g., in combined abdominoperineal resection of the rectum, it is used routinely at this clinic. In other instances some anomaly of the urinary tract may be present before operation but remain unrecognized until, during the postoperative period, it acts as a contributory factor in the urinary retention, e.g., benign prostatic hypertrophy or stricture of the urethra. When such conditions are present they must be treated according to accepted methods.

#### HEMORRHAGE

Hemorrhage after abdominal operations rarely occurs with modern methods of hemostasis, but when it does occur it may be unrecognized and lead to a fatal outcome. Before the knowledge of the role of vitamin K in patients with obstructive jaundice, hemorrhage after operation on patients with long standing obstructive jaundice was frequently seen. The bleeding in such cases was generally a slow general persistent ooze from the wound, and the loss of blood often was considerable. Usually the bleeding could be controlled by giving transfusions of fresh whole blood, but in one instance seen at the Cincinnati General Hospital repeated transfusions failed, the patient continued to bleed, and finally succumbed about one week after operation. At the present time the bleeding tendency in patients with obstructive jaundice can be measured by determination of the so called 'prothrombin time'. If the test shows that the prothrombin level is low, this can usually be corrected by giving vitamin K. Ordinarily one of the synthetic vitamin K preparations is given parenterally, several ampules a day, and operation is performed only after the prothrombin time has reached normal levels. Transfusion of fresh whole blood should be given during the operative procedure and repeated

after operation in small amounts when and if bleeding from the wound occurs. It is important that the dressing applied to the wound in these patients should contain relatively little padding and have free spaces between the adhesive tapes so that bleeding can be recognized promptly if it should occur. It is usually wise to leave a standing order specifying that the dressing be inspected at regular or frequent intervals and the doctor called if fresh bleeding occurs. During the past year, oxidized gauze and preparations of thrombin have been made available and the use of these aids during the operative procedure may help prevent bleeding after operation, though to date my personal experience with them has been limited and I cannot make positive recommendations.

Concealed hemorrhage into the peritoneal cavity occurs rarely, but may be overlooked, as it is usually symptomless until the patient goes into shock from loss of blood. The treatment is transfusion and re-opening of the wound to ligate the bleeding point.

Bleeding into a hollow viscus, for example, into the stomach after partial gastrectomy, occurs but rarely. I can remember but one such case at the Cincinnati General Hospital in the past ten years, and this is the only one I have seen. In that instance the treatment was similar to that for a bleeding peptic ulcer, and the patient made an uneventful recovery.

Bleeding from an infected drainage tract into the abdomen may be very troublesome and lead to serious consequences. Most cases are treated by exploration of the wound and preferably by ligation of the bleeding point, otherwise by packing.

### FISTULAS

Following many types of abdominal operations, fistulas of various sorts may develop, e.g., fecal, duodenal, pancreatic and biliary. While relatively rare in occurrence, considerable study, time and effort may be required to obtain a cure. There is great variation in individual cases, so that different forms of attack are necessary. Most postoperative fistulas are on a mechanical basis, and are more easily cured than spontaneous fistulas which are generally inflammatory. Many of the former tend to heal spontaneously though time and patience are required. Protection of the skin from the corrosive action of the fluid coming from the fistula often is necessary.

*Fecal fistulas* tend to close spontaneously if there is no intestinal obstruction below the fistula, and if there is no gross infection. Roentgenologic study of the intestinal tract to demonstrate patency of the lumen is one of the first investigations to be made. If no obstruction is present, and infection is not intense, one is justified in conservative management for a time. If the fistulous tract is relatively long it is more likely to heal than if it is short and broad. If everted intestinal

mucosa can be seen protruding, however, spontaneous healing is quite unlikely, and direct surgical attack is indicated. Usually the bowel can be freed sufficiently to invert the mucosa, often without entering the free peritoneal cavity, and the fascia and skin can be closed loosely after suture of the bowel. If considerable infection is present, the problem is more complicated. Two general forms of attack are commonly utilized. One consists of diverting the fecal current by a temporary complete enterostomy proximal to the fistula, and closure of the fistula after infection subsides. The other general method is to enter the peritoneum at some distance from the fistula, and anastomose the bowel around the fistula, followed at the same time or later by excision of the fistulous tract and the bowel from which it arises.

*Duodenal fistulas* are much more difficult to handle than those lower down in the intestinal tract. The protection of the skin is often in itself a problem of some magnitude, and the loss of fluids and electrolytes may lead to rapid depletion of the patient. Direct attack on the fistula is often difficult since the duodenum cannot be freely mobilized to get satisfactory closure. Although early direct surgical attack is usually recommended, many cases can be cured by less radical measures. In several patients seen recently the following plan was used. First a small mushroom catheter was inserted into a high loop of jejunum through a small incision in the left flank. Such a procedure can be carried out under local anesthesia. Two purse string sutures of 00 chromic catgut to invert the mushroom catheter as one does a Stamm gastrostomy suffice to hold the tube in place. This jejunal tube is for purposes of feeding, and a Scott Ivy jejunostomy feeding schedule is started. The skin around the fistula is protected by a thick coating of zinc oxide ointment. Zinc oxide powder mixed with castor oil to form a thick paste is quite satisfactory. A straight catheter is then inserted into the fistulous opening and connected with a continuous suction apparatus. A water pump such as that used in the laboratory for suction filtration has seemed to give the most satisfactory continuous suction. The fluid collected by suction is re fed through the jejunostomy tube and helps maintain fluid and electrolyte balance. The patient is given little or nothing by mouth. In cases in which the fluid cannot all be collected by aspiration the excess may be partially absorbed by Fuller's earth. Usually no gauze dressings are applied as they serve only to hold the irritating fluid in contact with the skin. The report of a case treated by this method follows.

Mrs J. Y. D. was admitted to the hospital December 29, 1944. She had previously had several operations performed in an effort to cure a postoperative complete stricture of the common bile duct. As a result of the last operation there developed a duodenocolic fistula in addition to obstruction of the bile ducts. The patient was deeply jaundiced. At operation a cavity was entered which communicated with the duodenum and colon and with a tiny tract ex-

tending into the hepatic duct system. The colon was mobilized, and the opening closed with catgut, reinforced with silk. The scarred lower end of the bile duct system was excised until a free opening was obtained into the dilated hepatic ducts and the lining epithelium could be clearly seen. This opening was practically flush with the undersurface of the liver. Mobilization of the duodenum to allow an accurate mucosa to mucosa suture was impossible, so one arm of a large T tube was inserted into the hepatic ducts, and the other arm into the duodenum. Purse-string sutures of catgut were placed around each opening, and the serosal surface of the duodenum was sutured as securely as possible to the fibrotic undersurface of the liver. The long arm of the T tube was brought out through the abdominal wound.

For several days after operation everything went well, but then drainage of bile appeared around the tube. Shortly thereafter gastric and duodenal contents began to drain copiously, and erosion of the skin developed. The wound separated slightly and by the seventh day, the T tube was extruded. When it became obvious that a biliary and duodenal fistula had developed, a jejunostomy tube was inserted for feeding and continuous suction was applied to the wound. Part of the fluid collected was re-fed each day through the jejunostomy tube.

after operation. Nothing by mouth except occasional sips of water was given for twenty days. As the fistula closed, feedings by mouth were started and as soon as it was deemed safe, the jejunal tube was removed. The patient left the hospital on February 7, 1945, the thirty-ninth day after the original operation. At the latest report, May 1, 1945, she is still doing well. Since satisfactory anastomosis of the bile ducts to the intestine was not accomplished it seems almost certain that recurrence of the bile duct stricture will develop and will probably necessitate re operation in the not too distant future.

*Pancreatic fistulas* are rare but have occurred in a few instances following radical resection of the duodenum and head of the pancreas for cancer of the ampulla or of the pancreas. In most instances they heal spontaneously and without difficulty. In one interesting case seen at this clinic the fistula failed to heal and finally had to be implanted into the intestinal tract.

C. C., a 62 year old white male laborer, was admitted to the hospital October 18, 1939. He was deeply jaundiced and a diagnosis of carcinoma obstructing the common duct was made. He was operated upon by a radical two-stage resection of the duodenum and head of the pancreas according to the method of Whipple and Parsons for adenocarcinoma of the ampulla of Vater, the first stage being performed October 31, 1939, and the second stage December 9, 1939. Following operation there developed a profuse flow of bile tinged fluid. Drainage of bile gradually decreased and after several weeks, ceased entirely, but pancreatic fluid continued to flow. The pancreatic fistula closed from time to time, but each time it closed the patient would develop chills and fever. He was admitted to the hospital five times during the next year to have the tract reopened. During this time he remained weak, diarrhea with foamy, fatty stools was persistent, and the red count and plasma proteins remained low. Pancreatic replacement therapy seemed to help him symptomatically. It was finally decided to implant

the fistula into the bowel, and on May 1 1941, the tract was followed down to the stump of the pancreas. The pancreatic duct was cannulated with a small vitalium tube, presented to me by Dr Herman Pearse of Rochester, New York, the other end of the tube being inserted into a loop of bowel.

The patient did very well following this procedure. The wound healed rapidly and the patient left the hospital on May 24 1941. He gained weight and strength, the blood count and plasma proteins returned to normal levels, and the diarrhea disappeared. A ray six months later showed that the tube was no longer in place. He has remained well. He worked at a war job until late 1944, when he had a rather severe heart attack, but I have been informed that he is now back at work again.



Fig 44\*—Cholangiogram using lipiodol injected through an external biliary fistula following drainage of the gallbladder. There is shown a complete obstruction of the common duct with dilated hepatic ducts. In this case a direct anastomosis of the common duct to the duodenum was performed.

*Biliary fistulas* following operations on the gallbladder or bile ducts are fortunately rare, but are often difficult to manage. They may, of course, be due to stones overlooked or not suspected in the common duct at the time of the original operation, or to trauma or stricture of the common bile duct. In the latter instance, the external biliary fistula may close completely and the patient may then develop a slow, painless, progressive jaundice of obstructive type.

If external fistula is present, a cholangiogram using a radiopaque fluid such as lipiodol or diodrast is indicated (Fig 447). The fluid



should be introduced under fluoroscopic control, and excessive pressure should be avoided. With satisfactory x rays, the nature and location of the obstruction can usually be determined with considerable accuracy. Sometimes a stone can be seen in the dilated common duct. If there is complete obstruction this can be clearly demonstrated. The operative procedure to be used can be planned on the basis of the roentgenologic findings. With stone, the operation is relatively simple but with stricture, it may be quite difficult, depending largely on the level of the obstruction and the amount of scarring and fibrosis. Some obstructions are so high that practically no extrahepatic bile ducts are present, and in such instances the operative treatment is unsatisfactory since exposure is difficult and suture almost impossible. In all these patients there is a tendency to bleed due to decreased prothrombin which can be measured by determining the prothrombin time. In the absence of bile in the intestinal tract, there is failure of absorption of vitamin K from the food, and the lack of absorption of this vitamin leads to disturbance in the clotting mechanism apparently due to failure of prothrombin formation.

If there is no external biliary fistula, the patient is jaundiced and no bile gets into the intestine. If there is an external fistula, the patient may be only slightly jaundiced or show no jaundice at all but the bile still is not getting into the intestine unless it is collected and re fed. It can therefore be seen that the absence of jaundice does not mean that the prothrombin time is normal. Before operation is undertaken, it is necessary to get the prothrombin time as near normal as is possible. This can be done most simply by giving synthetic vitamin K, two ampules per day parenterally, for five to seven days checking the prothrombin time every day or every other day. In cases with external fistula, the bile may be collected and re fed. This is best done by feeding it through a stomach tube twice a day, as most patients are unwilling or unable to swallow it. Still another method is to give dried bile salts in capsule form plus feedings of vitamin K by mouth. Combinations of these methods may be used, but in all instances prothrombin determinations should be made from time to time. Transfusions of small amounts of fresh whole blood usually stop the bleeding due to prothrombin deficiency, though the effect of such transfusion alone is transient, lasting only a matter of hours.

The method to be used in establishing a communication between the proximal bile duct and the intestinal tract will vary with the particular conditions existing in a given case. If the distal portion of the common duct can be found, direct end to end suture of the proximal and distal ends is indicated. It is important that the two ends be brought together without tension so that an accurate mucosa to mucosa suture can be made otherwise there is likelihood that a stricture will re form. Bile apparently has a stimulating effect on the forma-

tion of scar tissue and a tube lined by biliary or intestinal mucosa seems necessary in order for patency to be maintained.

Often the distal end of the common duct cannot be found, being completely buried in scar tissue, or largely destroyed and replaced by scar. In such instances, direct suture of the proximal bile duct to the intestine is indicated. If there is a considerable length of proximal distended common duct and not too much scarring, direct suture of the duct to the duodenum is the method of choice. The common duct is opened by a transverse incision as near to the duodenum as possible, and an opening the same size is made in the duodenum. A continuous suture of 00 chromic catgut on an atraumatic needle is then placed, uniting the mucosa of the duct to the mucosa of the intestine around the entire stoma. The suture line is reinforced anteriorly with interrupted sutures of silk (Fig. 448). I have used this method successfully

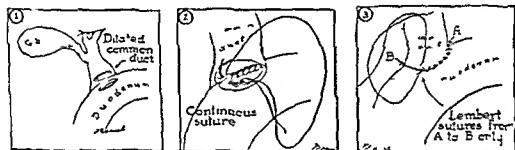


Fig. 448—Semidiagrammatic illustration of method of direct anastomosis of common bile duct to duodenum.

in six cases. If accurate mucosa-to-mucosa suture cannot be attained the anastomosis should be made over a tube. Many different sorts of tubes and methods have been described and recommended. One method is to insert an ordinary rubber catheter into the proximal bile ducts and allow about 4 to 5 inches to extend into the duodenum, relying on peristalsis to pull the tube into the bowel after a period of weeks or months. Suture of the mucosa of bowel to mucosa of duct should be carried out if possible and it is desirable that no actual loss of continuity be bridged by the tube, because stricture will almost certainly occur after the tube is withdrawn.

Several years ago Pearse<sup>5</sup> introduced the vitallium tube to be used in suture of the common duct. Vitallium is a chemically inert metal which can be left in tissues indefinitely without tissue reaction. Pearse recommended the tube for end to end suture of the common duct, but it has been used widely to anastomose the proximal end of the duct to the duodenum. I have personally used it in this manner in eight patients. The procedure is relatively simple, and the results have been quite satisfactory in a number of these. Two difficulties have arisen in my experience, namely, clogging of the tube with bile pig-



## POSTOPERATIVE VENOUS THROMBOSIS AND PULMONARY EMBOLISM

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### GENERAL CONSIDERATIONS

THE intravascular clotting of blood and the movement of such blood clots from one part of the vascular system to another may be responsible for some of the most serious complications which can follow in the wake of surgical operations. The physicochemical changes which produce such venous thrombosis do not differ greatly from those incident to the normal process of coagulation of blood, except that, under normal conditions, blood does not clot within the blood vessels during life. In those patients who develop venous thrombosis, with or without pulmonary embolism clotting of the blood goes far beyond normal limits and clots develop within blood vessels which show no obvious evidence of injury.

The factors which predispose or contribute to venous thrombosis may be numerous and not all instances of such intravascular clotting of blood can be completely explained on the basis of the classical triad of (1) the slowing of the circulation of blood (2) structural changes in the wall of the affected blood vessel, or (3) the increased coagulability of the blood.

The *slowing of the circulation* in itself will rarely cause intravascular clotting of the blood. It has been observed and commented upon many times that blood may remain fluid in a segment of vein which has been isolated between two ligatures providing the intima of the vein was not injured when the ligatures were applied. It is well established, however, that changes in the rate of flow of blood caused by the constricting action of tendons, muscles and fascia may predispose to the localization of the thrombosis to certain segments of the peripheral veins.

*Injury to the intima* of peripheral veins from mechanical, chemical or thermal agents is of considerable importance in the causation of localized thrombosis. The tearing, crushing or stretching of the intima associated with fracture of bones, sprains, gunshot wounds or similar injuries may produce relatively little damage to the outer coats of the

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veins yet cause sufficient trauma to the intima to precipitate thrombosis. Local infection, and particularly abnormal sensitivity of the tissues of an extremity to bacterial toxins or the by-products of certain fungus growths, also lead to localized venous thrombosis.

The *increased coagulability of the blood* must be considered as one of the most important factors which predispose to venous thrombosis yet the study of the degree of this hypereocoagulability has not received sufficient attention by clinicians. Local increase in the coagulability of the blood is mediated through the local liberation of *thrombokinase from injured tissue and must be considered as one of the important protective mechanisms of the body*, but this effect remains localized to the site of the injury. An increased tendency of blood to clot within normal veins anywhere in the body, especially in the extremities, is noted in patients with hemoconcentration from any cause, such as loss of plasma in burns, hemorrhage, shock or dehydration due to vomiting, sweating, or gastric suction. The increased viscosity of the blood in polycythemia vera and in the various types of organic arterial diseases also favors spontaneous thrombosis in the peripheral veins.

The problem is not as simple as Ochsner and DeBakey<sup>1</sup> seem to imply in most of their writings yet much good can come from a rational consideration of the problem on the basis of some of their fundamentally sound concepts. We must all agree that, from the standpoint of the mechanism of venous thrombosis, it is logical to assume that the simplest variety of venous occlusion unassociated with inflammation, with the clot loosely attached to the wall of the vein, is best described by the term *phlebothrombosis*, while the intravascular clotting of blood associated with and moreover dependent upon inflammatory changes in the wall of the vein, with the clot usually firmly attached, is best described by the term *thrombophlebitis*.

The most important considerations as far as the clinician is concerned, however, center around the origin of such blood clots and how they may be kept from being carried or extended to vital parts of the body. There is still considerable misconception concerning the role of the veins of the lower extremities in the production of such blood clots, for it is assumed by most doctors that serious pulmonary emboli usually come from blood clots in the pelvic veins or from the right side of the heart.

Some clinicians also consider pulmonary embolism as a catastrophe which usually makes its appearance, without special warning, in an otherwise healthy patient who has almost completely recovered from the effects of some surgical operation which was performed one or two weeks previously. Such a concept of pulmonary embolism must be considered archaic since it is now well established that this complication is even more frequent in patients who have been confined to

bed for some reason other than a surgical operation. This is particularly true of elderly patients who have been confined to bed because of heart disease or fracture of some long bone of the body.

The veins of the legs have been shown to be the most frequent site for active thrombosis and the most prolific source of both fatal and nonfatal pulmonary emboli. The local symptoms referable to such peripheral venous thrombosis may be slight or even absent, consequently most clinicians have ascribed very little importance to thrombosis of the veins of the calf or of the foot.

Most of the patients who have nonfatal pulmonary embolism usually have warnings as to what might happen but these warnings may be fleeting and are often considered unimportant by the attending doctors. Sudden pleuritic pain, with or without blood in the sputum, is frequently misinterpreted and the minor clinical symptoms of small pulmonary emboli are not given serious consideration.

The clinical problems which confront the surgeon in the management of patients with peripheral venous thrombosis or pulmonary embolism are numerous and controversial. The consequences of progressive thrombosis in the veins of the legs may be extremely serious and may justify heroic surgical procedures even when they are performed as prophylactic measures against pulmonary embolism. In the evaluation of the problem from the standpoint of definitive treatment the surgeon should never disregard the alterations in the clotting mechanism of the blood, the age of the intravascular blood clot, or the late effects of stasis of blood within the common femoral or iliac veins after ligation of the femoral vein at a point proximal to the profunda femoris tributary. No lasting benefit to the patient can result from the removal by suction or curettage of an old, well-organized thrombus from within the common femoral vein, or from a hastily performed ligation of both femoral veins when the intravascular clot has already extended into the iliac veins, or when the real source of the pulmonary emboli is in the heart.

While the danger of pulmonary embolism following peripheral venous thrombosis has recently aroused great interest in certain parts of this country, there has been a tendency to minimize the equally serious clinical problem of *residual edema, persistent pain* and even *ulceration of the skin* which may also follow extensive clotting of the blood within the veins of an extremity. The successful management of these late effects of venous thrombosis in the lower extremities is a problem in itself since they are also responsible for great disability, loss of many working hours and much suffering among patients in all walks of life.

The *prevention* of the complications which result from peripheral venous thrombosis is the *real solution* of the problem, but such a solution can only come as a result of a more universal understanding of

the contributing causes, the anatomic sites where most of the intravascular blood clots form, and the pathologic physiology concerned with the formation, propagation and dissemination of such blood clots in human beings

### ETIOLOGY OF VENOUS THROMBOSIS

From a clinical standpoint the consideration of the *predisposing factors* for venous thrombosis is of importance since the specific causes of intravascular clotting of blood are still unknown. The clinician should give first consideration to the study of the important predisposing factors. Peripheral venous thrombosis has been shown to be common in certain families, consequently, the probability of a constitutional diathesis to this condition should be given serious thought. The disturbance is rare in patients under 30 years of age and the types which are of greatest clinical importance usually occur in the fourth, fifth or sixth decades of life. Allen, Linton and Donaldson<sup>2</sup> found that 81 per cent of their series of 202 patients with thrombosis and embolism were over 40 years of age. According to McCartney's<sup>3</sup> studies this condition was present in 91 per cent of men and 112 per cent of women. In patients with heart disease, peripheral venous thrombosis occurs three times as often as it does in patients with normal peripheral circulation. It is interesting to note that persons with anatomically normal hearts show a slight but gradual increase in the incidence of thrombosis and embolism as the age advances, whereas persons with diseased hearts show these complications fairly uniformly in all decades of life after the first. Anderson<sup>4</sup> found that the average weight of patients with venous thrombosis or pulmonary embolism was 13 pounds above normal. Anemia and excessive use of tobacco predispose to peripheral venous thrombosis.

Ochsner and DeBakey<sup>1</sup> stress the fact that there is considerable variation in the incidence of intravenous clotting according to the seasons and according to the locality. It is believed by many clinicians that intravenous clotting of blood is more frequent in the spring and winter months and that the incidence is higher in the northern climes than elsewhere in this country. Faure<sup>5</sup> expressed the idea that the grippal infections were responsible for the increase in the incidence of thrombosis during the months from December to February. Ochsner<sup>6</sup> believes that the geographic variation is due to the vasospastic effect of cold upon the flow of blood in the extremities. DeTakats<sup>7</sup> and his co-workers studied 100 cases of pulmonary embolism and found the greatest incidence during the spring and fall and they concluded that these were the times of the year when the greatest fluctuations in barometric pressure and temperature take place. Martland<sup>8</sup> reported that March, April, September and December were months with the greatest incidence of pulmonary embolism. McCartney's<sup>3</sup> study of

material from the University of Minnesota Hospitals, covering a period of twenty years, failed to reveal any indication of seasonal variations in the incidence of thrombosis or embolism. The greatest number of patients with these complications have been reported from the New England States. Chronic upper respiratory infections and low temperatures have been ascribed by Allen to be important predisposing factors.

Neumann<sup>10</sup> stresses the importance of the anatomic structures which produce vascular stasis and predispose to thrombosis in the particular areas such as the plantar veins, the veins of the calf muscles, and the veins of the thighs. Fowler's position<sup>11</sup> causes stasis below the popliteal vein because of the pendancy of the leg and the compression or kinking of the popliteal veins. Friedlander<sup>12</sup> emphasized the fact that vascular stasis in the lower extremities is favored when the patient is in the prone position because of the uphill course of the femoral veins where they join the iliac veins.

The *composition of the blood* is definitely altered during and after any surgical operation or after extensive injuries. The increased coagulability of the blood is the result of physical and chemical changes in the blood plasma and in the formed elements of the blood. The changes in the blood plasma consist of an increased viscosity, hypoproteinemia, hyperglobulinemia, increased content of fibrinogen, increased peptidase and antitryptic activity, increased content of calcium and a decreased carbon dioxide combining power. According to von Seemen<sup>13</sup> the increased peptidase content of the plasma is the result of destruction of cells and such an aseptic destruction of the cells also produces a decrease in the anti-thrombin content with the result that there is an increased tendency for the blood to clot. There is a concentration of the globulin fraction in the blood plasma which results in a relative increase in its proportion to the albumin concentration causing a disturbance in the colloidal equilibrium of the blood plasma. Associated with this there is a disturbance in the ratio of calcium and potassium ions.

The *formed elements of the blood* also show changes. The thrombocytes and leukocytes increase and the erythrocytes tend to decrease in number. The increased agglutinability of the formed elements, particularly the thrombocytes has interested us a great deal. This phenomenon is ascribed to some change in the electrical charge of the formed elements with the loss of the normal repulsion between these formed elements. This increased tendency to agglutination causes clumping of the cells and may be partly responsible for the initiation of the process of thrombosis. Some investigators have suggested that the change in the electrical potential of the formed elements of the blood was primarily related to the disturbance in the albumin globulin ratio. Heusser<sup>14</sup> showed that the increased agglutinability of the



platelets actually paralleled the increased tendency toward intravascular clotting of the blood. He found that this change in the blood was particularly marked after most abdominal operations especially after hernioplasty operations and the change was greatest in older persons.

The *absorption of chemical substances* released from cells which are injured by the invasion of malignant tumors has been shown to increase the tendency of the blood to clot within the veins. This hypercoagulability is so great in some patients with a hidden malignant tumor that it has even been considered as a diagnostic test for cancer. Trousseau called attention to the fact that peripheral venous thrombosis is often the first clinical manifestation of an internal cancer.

The physical and chemical changes in the blood take place throughout the entire circulatory system and therefore do not completely explain why thrombosis occurs so frequently in the plantar veins of the feet, in the veins of the muscles of the calf and thighs or in the visceral veins of the pelvis. Ochsner<sup>8</sup> emphasizes that the chemical changes in the blood together with the physical factors which cause retardation in the peripheral venous circulation are essentially responsible for the type of intravascular clotting which he has called phlebothrombosis. In those patients in whom there is an inflammatory process in the wall of the vein the thrombosis is mainly the result of the injury to the endothelium by the invasion of the wall of the vein by bacteria which gain entrance through the perivenous lymphatic pathways. Only rarely is the intima of the vein attacked by bacteria which are present in the blood stream. Rokitsansky gave the name 'secondary phlebitis' to that type of involvement of the peripheral veins and described the condition as the result of actual pyemia.

The *application of excessive heat or cold* to the tissues of an extremity may cause damage to the intima of the blood vessels and precipitate intravascular clotting of the blood. Frozen extremities, immersion or trench feet and extremities which are the seat of structural disease of the arteries or arterioles may become serious clinical problems when the careless use of heat precipitates extensive clotting of the blood in the superficial veins. Degenerative changes in the large blood vessels in the form of atheromatous plaques in the aorta or other large arteries may give rise to local thrombosis and saccular aneurysms always contain some laminated blood clots.

The final *clinical syndrome* associated with peripheral venous thrombosis therefore, may represent a combination of many causes and many predisposing factors. Rossle<sup>10</sup> emphasized the fact that the muscles of the calf regions are pressed against the mattress when patients lie in bed. There is also abnormal pressure over the adductor regions in fat individuals whose thighs press together while lying in bed.

## SITES OF THROMBUS FORMATION

The movement of blood in the peripheral veins is dependent upon several different factors, the chief one of which is the squeezing action of the skeletal muscles when they contract. The negative pressure within the thorax and abdomen and the impelling force of the heart action upon the blood as it goes through the arterioles and into the capillary bed are also of importance. Ochsner<sup>6</sup> believes that the principal reason that the clotting usually occurs in the lower extremities is because of the great degree of vascular stasis in those parts of the body.

In 1929 Denecke<sup>17</sup> showed that the earliest clinical symptoms of thrombosis in the veins of the lower extremities appeared in the sole of the foot and in the muscles of the calf and he suggested that these were the initial sites for the formation of intravascular blood clots. In 1934, Homans<sup>18</sup> published clinical and pathological data to re-emphasize the importance of the veins of the muscles of the calf as areas of origin for ascending thrombosis.

Neumann<sup>19</sup> postulated two *clinical types* of venous thrombosis as based upon the site of origin of the blood clots, (1) a *benign variety* of thrombosis which starts in the veins of the legs and is characterized by slow progression of the thrombus. This type is more common as the age advances, with a definite tendency for multiple but usually nonfatal pulmonary emboli, and (2) a *malignant form* of thrombosis which starts in the plantar veins and is characterized by a rapid progressive thrombosis which usually occurs in younger patients without any increase as age advances but with a distinct tendency toward fulminating and fatal pulmonary embolism. He expressed the opinion that the large emboli of both types come from that portion of the thrombus which is extended into the veins of the thigh. Of his patients with thrombosis of the veins of the legs, 11.8 per cent had fulminating, fatal pulmonary embolism and of these more than 80 per cent had blood clots in the veins of the feet and legs. If we consider nonfatal or multiple pulmonary emboli then the lower extremities account for 52.8 per cent of all the clots which are transported to the lungs.

Other studies have given similar information, and Hunter and his co-workers<sup>19</sup> recently reviewed their own material and re-emphasized the fact that thrombosis of the deep veins of the legs is appallingly frequent among middle-aged and older patients who are confined to bed for varying periods of time, and they found evidence of peripheral venous thrombosis in 52.7 per cent of their patients.

## TYPES OF VENOUS THROMBOSIS

The simplest form of venous thrombosis exists as *localized superficial phlebitis* in preexisting varicose veins. This type of thrombosis

may ascend to the groin but rarely gives rise to serious complications. The ascending thrombosis which begins in the plantar veins is most frequently seen in young ambulatory individuals and frequently gives rise to pulmonary embolism. The *thrombosis of the veins of the calf muscles*, as described by Homans,<sup>18</sup> usually shows no plantar vein involvement but is characterized clinically by an aching cramplike pain in the calf of the leg with definite spasticity of the calf muscles. There is distinct pain on dorsiflexion of the foot as emphasized by Homans, and usually there is an increase in the temperature of the skin over the calf muscles. The femoral vein is usually not tender and the patient shows no fever or leukocytosis. This thrombotic process may ascend to the popliteal or femoral veins after which it is less likely to give rise to pulmonary emboli. This condition occurs more often in the older patients who are immobilized and it is the type of peripheral venous thrombosis which remains latent and unrecognized until pulmonary embolism occurs.

*Pelvic vein thrombosis* is usually characterized by pain and swelling in the buttocks or adductor muscles close to the inguinal folds and is usually associated with pains along the sciatic nerve and may cause frequency of urination or slight diarrhea. Pelvic examination some times reveals palpable cords at the site of the large veins in the pelvis. As long as the thrombosis remains localized to the pelvic veins, there is little danger of pulmonary embolism.

The clinical distinction between *thrombophlebitis* and *phlebotrombosis* is emphasized by Ochsner and DeBakey and concurred in by Homans, Arthur Allen and many other surgeons. It is now well established that thrombophlebitis which involves the iliofemoral segments is a fully obstructing type of thrombosis associated with definite perivascular inflammation and enlargement of the regional lymph nodes. The thrombus in this segment is so firmly attached to the wall of the vein that embolism need not be feared. The greater the swelling and discomfort the less will be the danger that a soft detachable mass exists. When pulmonary embolism occurs under such conditions one can be reasonably certain that it does not come from the veins of the swollen limb but rather from the veins of the innocent appearing other lower extremity.

In patients with *phlebotrombosis* there is a soft, nonobstructing and detachable blood clot within one of the larger peripheral veins and there is little evidence of perivascular inflammation. The danger of pulmonary embolism under such circumstances is great.

From the standpoint of the pathologist, however, such a clinical distinction has validity only in that there are many gradations in the process and different proportions of perivascular inflammation, soft loose blood clot or adherent thrombus within the veins. It is almost impossible in any given patient to tell whether or not a soft blood clot

is present within the affected vein regardless of the estimated degree of thrombosis which is present

*Traumatic or mildly infected thrombosis* might propagate as a bland, red thrombus which is nonadherent and which could break off easily and give rise to pulmonary infarction, consequently simple phlebothrombosis might develop into an inflammatory periphlebitis when it ascends to the level of the inguinal region where the lymphatic vessels or lymph glands may harbor bacteria

*Thrombophlebitis* may develop either in normal or in diseased veins. Involvement of the *cavernous sinus* within the skull fortunately occurs infrequently and usually results from maltreatment of some suppurative lesion in the regions about the eyes or nose or on the upper lip. The inflammation reaches the cavernous sinus by way of the facial, angular and ophthalmic veins and some of the factors which are responsible for this spread are thought to be the muscular character of the upper lip, the active movement of which exerts a pumping action on the venous plexuses in the lip together with the inability of these veins to completely collapse and hinder the flow of blood toward the venous sinuses within the skull

*Thrombophlebitis of the portal vein* following suppurative processes within the abdomen, especially in the region of the cecum, is much more frequent than the surgical literature seems to imply. Gage, Garside and Ochsner<sup>70</sup> reported thrombophlebitis of the portal vein or its tributaries in as high as 1 per cent of all cases of acute appendicitis and in nearly 5 per cent of all patients who died of peritonitis resulting from gangrenous appendicitis. Involvement of the *ovarian and hypogastric veins* usually follows suppurative processes within or around the uterus. Puerperal infections and pelvic peritonitis following septic abortions usually give rise to varying degrees of thrombophlebitis of the veins which drain the respective areas

*Varicose veins* of the lower extremities and *hemorrhoids* are the diseased veins of the body which are frequently sites of origin of thrombophlebitis; however, most of these are of the nonsuppurative type and may give rise to the clinical syndrome called *phlegmasia alba dolens*

The *pathologic changes* which characterize thrombophlebitis are those which occur in the perivenous tissues and those which take place in the wall of the vein itself. The perivenous changes consist principally of a lymphangitis and, according to Koester,<sup>21</sup> the thrombophlebitic process is in reality a lymphangitis of the veins in which the infection is carried to veins by way of the lymphatic vessels. The perivenous inflammation causes the liberation of a fibrinous exudate into the perivascular spaces and this accumulation of perivascular fluid results in swelling of the part. The changes within the wall of the vein consist primarily of dilatation of the small blood vessels, cellular and

serous exudates about the vein and destruction of the endothelium of the vein. The injury to the intima is probably responsible for the thrombosis.

In some instances of *phlebothrombosis* there are no demonstrable changes in the endothelium of the affected veins and we must assume that the thrombosis resulted from some physicochemical changes in the blood. Stasis of blood in certain veins of the body is supposed to account for the localization of the thrombosis.<sup>11</sup> The thrombus in this type of venous occlusion is quite similar to an extravascular blood clot and it has been called a red thrombus or a coagulation thrombus. It is not firmly attached to the wall of the vein and is therefore particularly likely to give rise to pulmonary embolism.

The *amount of edema* which is present after thrombosis of the peripheral veins depends upon the extent of the blocking of the collateral venous pathways, the extent of the periphlebitic obstruction to the lymphatic channel, and the degree of vasospasm which has been brought about by the venous thrombosis. All of these factors may be present in the same patient but in varying degrees and, therefore, each must receive adequate attention when one is planning a therapeutic regimen.

#### CLINICAL ASPECTS OF VENOUS THROMBOSIS

In those patients who are confined to bed and then develop peripheral venous thrombosis, the pain is usually of a constricting, aching, boring, or burning variety. The discomfort is usually intermittent and does not depend upon the movement of the extremities. The pain is usually worse when the patient is in the standing position and very often the first sign of peripheral venous thrombosis is noticed by the patient when he is allowed to stand up after being confined to bed for a long period of time.

In those patients who are active at the time venous thrombosis takes place the pain usually comes on suddenly and is persistent and nearly always localized in the muscles of the calf. Edema of the foot and leg is rarely the first evidence of peripheral venous thrombosis.

The most common sign of venous thrombosis in the extremities is tenderness in some portion of the calf muscles. In order to test this tenderness the leg should be slightly flexed so that the muscles of the calf are relaxed. There should be fingerpoint tenderness along the course of the deep veins if venous thrombosis is present. The area of tenderness is usually small and well localized and can be easily overlooked. Forceful dorsiflexion of the foot with leg extended causes pain in the calf or popliteal areas if venous thrombosis is present. This sign, which was described by Homans, is not to be considered as pathognomonic, since it is positive in a variety of other conditions including peripheral neuritis, paralysis of muscles with foot drop, poliomyelitis

and myositis. Phlebothrombosis of the small vessels of the leg is usually not associated with fever or increased leukocyte count in the blood but such signs of inflammation are almost always present if acute iliofemoral thrombophlebitis has developed

#### PHLEBOGRAPHY

A great deal of experience is sometimes necessary to interpret the variation in the normal venous patterns as shown in the phlebograms. This fact, together with the knowledge that much simpler clinical methods will usually permit a definite diagnosis of peripheral venous thrombosis certainly limits the usefulness of this special diagnostic test. Fine and Starr<sup>22</sup> found on further analysis of their own material that the first clinical signs of peripheral venous thrombosis were present even in the absence of phlebographic evidence of obstruction. Spastic irregularity of the vein or even spastic obliteration of a vein may occur as a result of the concentrated diodrast solution and the resulting phlebogram would be indistinguishable from those obtained in patients who have definite organic occlusion of the veins. They pointed out that pulmonary infarction has resulted from clots which originated on the side of the body which was considered uninvolved by previous phlebograms. We are also of the opinion that the injection of concentrated diodrast solution (35 to 50 per cent) may cause some intimal damage and, in certain patients who already have some disturbance in the clotting mechanism of the blood, the introduction of any foreign substance might have a tendency to increase the coagulability to such a point that further spontaneous venous thrombosis takes place. We do not believe that the information which usually can be derived from phlebograms is in keeping with the hazards, inconveniences and expense of obtaining such phlebograms.

#### PREVENTION OF VENOUS THROMBOSIS

There are probably many factors which influence the return of blood from the deep veins of the extremities. It is well known that the effectiveness of the action of the heart which directly controls the circulation time of the blood and the squeezing action of the contractions of the muscles of the extremities on the veins are the two most important factors in keeping up the efficiency of the return of blood to the heart. To these factors of course, one must add the maintenance of normal negative pressure within the abdomen and the thorax and the elimination of all forms of mechanical obstruction to the return flow of blood. Gravity may either hinder or accelerate the return of blood to the heart. One must keep all of these factors in mind if phlebothrombosis is to be prevented. It would be unscientific to give active treatment for the weak heart muscle and at

the same time allow fluid to collect in the pleural and peritoneal cavities, to fail to relieve abdominal distention from any cause, to neglect the value of deep breathing or allow the extremities to become cold or to remain in the pendent position for long periods of time. The contractions of the muscles of the extremity are highly important means of securing and maintaining normal flow of venous blood in the legs.

In combating the retardation of the flow of blood most surgeons are cognizant of the importance of early mobilization of patients. Obviously many patients cannot be mobilized for eight to twelve weeks, especially those suffering from abdominal infections or fractures. DeCourcy<sup>11</sup> showed that elevation of the foot of the bed by a chair or wooden blocks is an excellent simple procedure for accelerating the venous return from the lower extremities. DeTakats has emphasized the importance of including the pelvis in this postural drainage. The use of the stationary bicycle has been supplanted by the active flexion and extension of the feet and flexion of the knees. The exercise of the calf muscles is an excellent means of emptying the veins of the extremities but such measures have definite contraindications and limitations.

Certain drugs have been shown to reduce the tendency of the blood to clot. Prostigmine and the inorganic sulfur compounds have been shown by deTakats and his co-workers<sup>12</sup> to decrease the clotting time of blood. Sodium tetrathionate in doses of 0.6 gm. per 1000 cc. of physiologic salt solution may be given intravenously both preoperatively and postoperatively until the clotting mechanism returns to normal. Prostigmine may likewise be used after major surgical operations because of its beneficial effect upon the clotting mechanism of the blood.

It is now possible to prevent excessive clotting of the blood with the nontoxic anticoagulants such as heparin and dicumarol. In order to use such drugs, however, it is necessary to use sensitive means of determining changes in the clotting mechanism. The ordinary clotting time and bleeding time tests do not reveal clear cut changes but the determination of the prothrombin time on dilute blood plasma does provide a means of detecting a tendency toward increased clotting of the blood. These tests, however, require a skilled technical assistant.

The response to heparin of patients who show signs of thrombosis in peripheral veins has been shown by deTakats<sup>14</sup> to be slightly diminishing and thus decreased heparin tolerance has been used for estimating the increased clotting factor. The *heparin tolerance test* is performed by injecting 10 mg. of purified heparin intravenously. The coagulation time of the blood is determined by the capillary tube method after 10, 20 and 30 minutes have elapsed. A flat toler-

ance curve indicates the presence or imminence of thrombosis. The normal response of the clotting mechanism can then be restored by heparin, dicumarol, the inorganic sulfur compounds, or prostigmine, and patients who are sensitive to heparin can be detected by this test.

### TREATMENT OF VENOUS THROMBOSIS

**Conservative Methods of Treatment**—The immobilization and elevation of extremities which are the seat of extensive venous thrombosis have been the chief measures of active therapy for decades. The patients are kept at absolute bed rest for many weeks and only the local application of heat to the affected thigh is advised. The residual edema which persists usually necessitates the use of an elastic stocking from the toes to the groin for many months. Many of these patients develop pulmonary embolism or chronic induration of the tissues of the lower legs. If the venous thrombosis is well localized the edema of the extremity will be slight, so the use of an elastic stocking in such cases will give relief of symptoms and a reasonably good end result. The loss of working hours during and following this type of treatment is great and there still remains the danger of involvement of the other extremity in about one third of the cases.

Zimmermann and deTakats<sup>5</sup> showed that the protein content of fluid from a swollen, thrombophlebitic extremity is high and the fluid is easy to mobilize in the early stages of the process but delay in starting active treatment may give this fluid time to clot and the resulting fibroblastic reaction usually produces irreversible changes in the tissue. Every effort must be made therefore, to keep the swelling of the extremity at its minimum level throughout the course of active treatment of venous thrombosis.

The *vasomotor instability* which usually results from the thrombosis of large peripheral veins has been shown by several different observers to be responsible for many of the signs and symptoms. The prolonged vasodilatation which results from intramuscular injection of the synthetic estradiols especially *estradiol dipropionate*, through liberation of an acetylcholine like substance in the tissues has proved to be an effective means of controlling this secondary peripheral vasospasm. McGrath and Herrmann<sup>6</sup> suggested the use of 10 mg. of di-ovocilin intramuscularly three times each week for about six weeks as an effective means of reducing the signs and symptoms of chronic or long standing types of venous thrombosis.

**Anticoagulant Therapy**—When an immediate effect upon the clotting time of the blood is required we believe *heparin* should be given by the continuous intravenous drip method. Heparin is an active antiprothrombin which acts directly upon the circulating prothrombin and prolongs the clotting time of blood. If the clotting time



of blood is kept at about fifteen minutes the extension of the thrombosis will be prevented but there will be no effect upon the blood clots which have already formed. There have been reports of propagation of the thrombosis with subsequent pulmonary embolism while patients were receiving heparin or immediately after the administration of heparin was discontinued. This has never happened to any of the patients in our clinic.

Heparin is difficult to use because it must be given by the continuous intravenous method if the clotting time of the blood is to be kept prolonged at all times. DeTakats<sup>2</sup> has suggested the intravenous injection of 50 mg. of heparin every four hours because it is a simpler method for the patient. The protective value is not as good owing to the fact that the clotting time of the blood fluctuated greatly between the injections.

Patients vary considerably in their sensitivity to heparin so the dose of the substance must be calculated for each patient on the basis of the effect of the original dose of 300 mg. in 1000 cc. of normal saline or 5 per cent glucose in saline solution. This should keep the average patient properly heparinized for twelve hours when this amount of fluid is allowed to enter the vein slowly by the continuous drip method.

The isolation and synthesis of *dicoumarin* [3,3'-methylene-bis-(4-hydroxycoumarin)] by Link and his associates<sup>27</sup> has given further impetus to the prevention and conservative management of postoperative venous thrombosis and pulmonary embolism. A deficiency in the production of prothrombin by the liver becomes apparent within 24 to 48 hours after the oral administration of *dicumarol*. This moderate deficiency in prothrombin is effective in preventing postoperative thrombosis.

When a rapid anticoagulant effect is needed, as in cases of massive pulmonary embolism, administration of heparin and *dicumarol* should be started simultaneously. The prothrombin time may be used as a guide to the effect of the *dicumarol* alone if the blood is drawn for the test within four hours after the heparin is introduced into the venous system. Heparin should be discontinued as soon as the prothrombin time drops to 30 per cent of normal.

Patients who have had thrombophlebitis or small pulmonary embolism rarely receive heparin in addition to *dicumarol* and have not observed progressive thrombosis or embolism during the time necessary for the *dicumarol* to cause an adequate deficiency in the prothrombin formation. The effect of *dicumarol* may continue for from two to ten days or longer after the last dose has been given. Daily prothrombin time tests should be continued until near normal levels of prothrombin time have been reached.

The administration of *dicumarol* should be continued until at least

one week after the patient has become ambulatory. The thrombosing tendency within the veins has almost certainly disappeared by that time. It must be emphasized, however, that when the prothrombin has returned to normal there is no further protection against thrombosis.

The only known hazard in the administration of dicumarol to patients after surgical operation is the risk of bleeding. From recent reports one must conclude that this risk has been overemphasized.

Barker and his co-workers<sup>78</sup> at the Mayo Clinic in their study of 1000 patients who were given dicumarol found the incidence of bleeding to be very small. Minor bleeding consisted of mild epistaxis, microscopic hematuria and slight oozing from the wound. These effects may or may not have been caused by the prothrombin deficiency. Major bleeding when it occurred almost always came from surgical wounds, particularly the vaginal wounds among patients on whom total abdominal hysterectomy had been performed.

When an operation is contemplated in patients receiving dicumarol the surgeon must allow ample time for the return of prothrombin time to normal before the operation is begun.

If an *emergency operation* becomes necessary when the prothrombin time is prolonged due to dicumarol then a large dose (60 mg) of *menadiolone sodium bisulfite* (synthetic vitamin K) and a *transfusion of fresh, whole blood* should be given before surgical procedure is undertaken.

Patients show considerable variation in sensitivity to this substance. Absorption of dicumarol from the intestinal tract probably varies in different patients and there is some evidence to show that this effect may vary with the body weight. The presence of fever, toxemia, and impaired nutrition also may influence the effect but there are still other unexplained differences in sensitivity to dicumarol. For these reasons it is necessary to individualize carefully the rate of administration of the drug to each patient.

Dicumarol should not be used unless daily and comparable prothrombin time tests can be done, since without these it is impossible to be certain whether insufficient, adequate, or excessive and possibly dangerous effects have been produced.

The dosage of dicumarol for the average patient is 300 mg in a single dose by mouth on the first day, 200 mg on the second day and 100 mg each day thereafter until the prothrombin time is greater than 27 seconds (30 per cent of normal plasma). Venous thrombosis will not take place if the prothrombin time is kept at that level.

We have also chosen to use this level of 27 seconds prothrombin time corresponding to 30 per cent of normal plasma as the optimum level, and the dosage of dicumarol should be adjusted to keep this level of prothrombin deficiency as constant as possible.

*Control of Bleeding and Excessive Prothrombin Deficiency*—If it becomes advisable because of hemorrhage or excessive prothrombin deficiency to partially restore the clotting power of the blood a *transfusion* of 500 cc of freshly drawn, citrated, whole blood is indicated. This effect is due simply to replacement of prothrombin and for that reason stored (bank) blood is not to be used. It may be necessary to repeat the transfusion of fresh blood several times over a period of two or three days since there is a tendency for the prothrombin to lessen in amount after several hours.

Some patients have been observed who show abnormal sensitivity to dicumarol. In such patients the prothrombin level may fall to less than 10 per cent of normal after the first day or so or even after any subsequent dose of dicumarol. Barker<sup>23</sup> reported ninety-four such patients. Most of these patients did not have venous thrombosis or pulmonary embolism.

We have followed the suggestion of Barker and give large doses of menadione sodium bisulfite to all patients whose prothrombin time falls below 10 per cent of normal after the administration of dicumarol, and then use smaller doses of dicumarol afterwards. If the bleeding is alarming, this drug should be given in addition to frequent transfusions of freshly drawn, whole blood. The danger of bleeding in any patient who has had venous thrombosis or pulmonary embolism is small.

*Contraindications to Use of Anticoagulants*—The presence of any blood dyscrasia which produces a tendency to bleed or any form of purpura is considered a contraindication to the use of either heparin or dicumarol. Patients with definite hepatic insufficiency or hepatogenous jaundice, especially if associated with prothrombin deficiency, should never be given dicumarol. Patients with renal insufficiency, active tuberculosis, open wounds or potential bleeding surfaces should be given heparin or dicumarol with great caution. Dietary or nutritional deficiency should preclude the use of either heparin or dicumarol.

*Röntgen Ray Therapy*—DeTakats<sup>7</sup> has continued to advocate the use of x radiation as active treatment for the periphlebitic exudation concomitant lymphangitis and lymphadenitis which he believes is the result of extensive venous thrombosis. The dosage and the timing of the repeated doses are of great importance. If in acute phlebitis a dose of 200 roentgen units is given a serious general reaction with chills, fever and malaise may occur. DeTakats reports that even a 30 to 40 per cent of an erythema dose of roentgen ray (125 to 135 roentgen units) with heavy filtration may produce a rise in temperature over the affected veins. If such doses are given too close together, exacerbation of the phlebitis may result. In the mild forms of thrombophlebitis 80 roentgen units through filters of 2 mm of aluminum and

0.25 mm of copper should be given at one week intervals. Such radiation therapy relieves the pain of chronic phlebitis and may reduce the edema.

#### PRESENT SURGICAL TREATMENT

After thrombosis of the peripheral veins once takes place the objects of treatment are to limit the extension of the process of thrombosis, to prevent fragments of blood clot from becoming dislodged, to prevent pulmonary infarction, and to correct the local impairment of the venous circulation in the affected extremity.

It must be emphasized that the present status of surgical therapy of peripheral venous thrombosis is still confused and leaves much to be solved before it can be considered as the ideal prophylaxis against pulmonary embolism. Even when surgical therapy is promptly applied, occasions will always arise when heparin or dicumarol may be a valuable adjuvant in the proper management of the disturbance.

**Ligation of Major Veins**—Those interested primarily in the surgical treatment by ligation of the femoral veins do not all agree on the absolute indications for such operations. Many surgeons are now of the opinion that if a patient shows signs of pulmonary infarction, the source must be carefully investigated and if it is found that the veins in the calf muscles of the legs are involved, the femoral vein below the profunda femoris tributary should be tied at once. They also believe that patients who present recognizable thrombosis in the calf muscles less than one week old and who must be kept in bed for some other reason, should be treated by ligation of the femoral vein. Often a floating thrombus will be found in the common femoral vein. On the other hand if a patient is seen with a tender swollen thigh or groin the clot within the vein should not be aspirated nor should the vein be ligated above the profunda femoris tributary. If the thrombosis is below the knee and the patient has been ambulatory for more than a week and there has been no extension of the thrombosis into the thigh, then the femoral vein should not be ligated.

*Ligation of the femoral vein below the profunda femoris tributary when the profunda femoris is patent results in relatively little edema, while ligation of the femoral vein above the profunda femoris tributary usually results in considerable edema. We also believe that ligation of the femoral vein following aspiration may give rise to thrombosis of the previously unobstructed collaterals and thus produce massive edema.*

While edema, cyanosis and pain may persist or even increase after iliac or femoral vein ligation, it is impossible to determine how persistent these signs and symptoms might have been had no ligation been done. Homans states that the edema due to ligation of the iliac vein is less pronounced than when the common femoral veins are interrupted. Fine and Starr have reported an occasional occurrence of pul-

monary infarction and only rare instances of fatal pulmonary embolism following ligation of the femoral veins

One of the greatest difficulties is to estimate the age of the clot at the level of exposure. The clot is usually much older than it appears to be and when it is firmly adherent to the wall of the vein the aspiration of the clot from the proximal segment is difficult and may leave small mural thrombi which may cause further intravascular clotting. At this stage the clot has completely lost its embolizing property. When the clot is fresh friable and nonadherent its presence does not give rise to pain or edema in the thigh yet this is the most dangerous variety and the one which should be treated by femoral vein ligation early in the course of the process.

Our experience has led us to the conclusion that the ligation of the femoral vein below the profunda femoris branch is occasionally indicated after pulmonary infarction has taken place and the site of the thrombus is definitely localized in the veins of the calf muscles and the thigh is not swollen and the femoral vein is not tender. Much less of an indication for ligation of the femoral vein exists when the patient has fully developed iliofemoral thrombosis when the femoral vein is tender and the clot within the vein is adherent and difficult to extract even by suction. In such cases we believe that operation is unnecessary unless one wishes to ligate the common iliac vein an operative procedure which is still in an experimental stage.

Fine and Starr<sup>22</sup> state that since the frequency of bilateral involvement is high they advocate *bilateral ligation of the femoral veins* even when there are relatively few symptoms of venous involvement in the opposite extremity. The level of ligation of the large veins they feel should be based upon evidence of extent of involvement. (1) The common femoral vein should be ligated when thrombophlebitis is limited to the veins below the knee or when pulmonary embolism has occurred in the absence of all signs of venous involvement. (2) The common iliac vein should be ligated when thrombophlebitis involves the common femoral the external iliac or the common iliac veins. (3) The vena cava should be ligated when there are indications that both common iliac veins require ligation.

**Novocainization of Regional Sympathetic Ganglions**—This procedure is commonly referred to as a paravertebral block and has been widely used to give relief of swelling and pain in the acute phases of thrombophlebitis. On the basis of experimental observations Albert<sup>30</sup> suggested the procedure to Leriche for clinical application. In 1934 Leriche and Kunlin<sup>31</sup> described the method of infiltrating the regional sympathetic ganglions with 2 per cent solution of procaine hydrochloride to overcome the secondary vasospasm associated with acute post-operative thrombophlebitis. Their reports indicate that most of their patients were relieved of their symptoms by this paralysis of the vaso-

motor nerves to the affected extremity. In 1939 Ochsner and DeBakey<sup>32</sup> confirmed these results and suggested that the method of treatment be applied more widely

Proper novocainization of these ganglions will usually *relieve pain, reduce the edema* of the part and *restore the arterial pulsations* to a normal level. The beneficial effects of this simple therapeutic procedure in the chronic phase of iliofemoral thrombophlebitis which has caused considerable chronic swelling and severe neuritic pain of the type which is influenced by changes in weather, have frequently been very striking. The period of disability in this type of patient can usually be shortened by this method of treatment.

In the University Hospitals we now use this method of treatment in those patients who have demonstrable arterial spasm in an extremity associated with thrombophlebitis. These patients usually have cold, cyanotic toes and suffer great pain. Patients whose toes are warm and who show other evidences of inflammatory hyperemia in the tissues of the affected extremity are not greatly benefited by this method of treatment.

The surgeon must constantly keep in mind that the blocking of the sympathetic impulses to an affected extremity does not protect the patient from pulmonary embolism nor will it protect him from residual edema if the extent of the thrombosis is great.

#### THE PROBLEM OF PULMONARY EMBOLISM

In a discussion of this type we need not review the clinical picture of massive pulmonary embolism which completely obstructs the main artery or its branches and which kills the patient in less than ten minutes. Before pulmonary embolism can take place there must be thrombosis of a vein elsewhere in the body. Small nonfatal emboli frequently come from the auricle on the right side of the heart.

It has been shown that about 8 per cent of the patients die in less than ten minutes, 33 per cent die in less than one hour and approximately 60 per cent of the patients with fatal pulmonary embolism live for one hour to several days. Such figures, of course, refer only to fatal pulmonary embolism and studies from the Mayo Clinic indicate that only about 20 or 25 per cent of these emboli are fatal in the first insult.

DeTakats<sup>7</sup> has reemphasized the importance of recognizing the early signs and symptoms and has instructed his interns and nurses to be on the constant lookout for the early manifestations of pulmonary embolism. The rationale for this type of emergency treatment is based upon the assumption that a large pulmonary embolus gives rise to abnormal reflexes in the autonomic nervous system in addition to the asphyxia, heart failure and insufficient return of venous blood to the

monary infarction and only rare instances of fatal pulmonary embolism following ligation of the femoral veins

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the veins of the extremities must be prevented if possible by frequent change of position in bed, elevation of the foot of the bed and above all active movement of the muscles of the lower extremities

We are convinced that a careful preoperative study of the clotting mechanism in patients who are to be subjected to extensive surgical operations or who, because of serious injuries, will be confined to bed for long periods of time, is of real importance as an aid in the prevention of venous thrombosis and pulmonary embolism. The heparin tolerance test or the prothrombin time test permits the detection of hyperprothrombinemia. These tests also help determine the activity of the thrombosis and indicate the possibility of further extension of the intravascular blood clot.

At the present time the surgical treatment is largely confined to limiting the process of thrombosis to an extremity and the prevention of pulmonary embolism. The prophylactic occlusion of a major venous pathway which could permit the propagation or transportation of a blood clot to some vital center of the body may be a life saving procedure and should be considered if the clinical signs indicate progressive venous thrombosis in the large veins of the extremities.

Our experiences have led us to conclude that the proper use of anticoagulants is a satisfactory *prophylactic measure* against pulmonary embolism when (1) the source of the emboli is not detectable clinically (2) venous thrombosis and pulmonary embolism have occurred before operation, and (3) chemical tests reveal hyperprothrombinemia. In patients with known venous thrombosis we believe that adequate treatment with anticoagulants will prevent pulmonary embolism because the propagation of the blood clot is prevented and fresh soft clots no longer form within the veins. The old thrombus remains firmly attached to the wall of the vein and will not give rise to pulmonary embolism.

All of the present methods of therapy have their limitations and it is not yet possible to assure every patient of complete recovery even if all methods of treatment were to be employed simultaneously. Regardless of the type of therapy which the surgeon wishes to use, we believe that the early recognition of the peripheral thrombosis is essential to proper therapy.

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## POSTOPERATIVE PULMONARY COMPLICATIONS

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It has been estimated in various surveys that postoperative pulmonary complications occur in from 2 to 5 per cent of all patients subjected to surgical procedures and that such complications account for 0.5 to 1.5 per cent of all surgical deaths. Other studies indicate that the incidence of serious pulmonary complications in major abdominal procedures rises as high as 10 per cent. And to the thoracic surgeon, the danger of fatal pulmonary complications is an ever-present menace. It is only natural, then, that the subject of postoperative pulmonary complications should be one of the greatest moment to all surgeons. The statement, frequently made, that the incidence of postoperative pulmonary complications has shown no appreciable decrease in the past fifteen years, however, must be qualified lest it be misleading. As Veal and Van Werden<sup>1</sup> succinctly point out, "The incidence of pulmonary complications after operation has almost invariably shown an *increase* when surgeons have devoted themselves to the subject, though with the increased incidence has usually gone a *decrease* in the mortality. The explanation is not difficult: better diagnosis and more careful observation explain the increase in incidence; better prophylaxis explains the decrease in mortality." This has been our own experience. Over the past decade we have been increasingly more aware of atelectasis, postoperatively, but the incidence of postoperative pneumonia has shown a steady decline. Postoperative pulmonary infarction is recognized far more frequently, while the incidence of fatal pulmonary embolism and abscess following surgery has gradually receded.

It is convenient for the present discussion to classify postoperative pulmonary complications as follows: atelectasis, pneumonia, embolism and infarction, lung abscess and fat embolism.

### ATELECTASIS

Since atelectasis constitutes so large a proportion of postoperative pulmonary complications, and since it is the precursor of many of the more serious postoperative pulmonary lesions, considerable space will be devoted to the discussion of this disturbance. In so doing, many of

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the considerations pertinent to subsequent topics will be discussed under atelectasis, holding in mind their applicability to pneumonia and lung abscess. The word atelectasis was coined by Jorg<sup>2</sup> in 1832 from the Greek words *ateles*—imperfect and *ektasis*—expansion, to denote failure of expansion of the lungs of the newborn. Twenty years ago, the only form of atelectasis recognized was what we designate today as massive collapse of the lung. Increasing clinical and experimental investigation, however, has demonstrated that failure of expansion, postoperatively, is a phenomenon which may have a lobular or lobar distribution in addition to involvement of an entire lung, that while massive collapse of a lung is a most infrequent occurrence, lobular atelectasis is by far the most common postoperative pulmonary complication, that what had formerly been diagnosed as early pneumonia is, in the great majority of instances, atelectasis, and that, with atelectasis as the most frequent precursor of pneumonia, postoperatively, its prevention or vigorous treatment has markedly reduced the incidence of pneumonia as a postoperative complication.

There is no unanimity of opinion among students of this disease regarding its etiology. Various theories have been offered to explain its mode of development. It is neither possible nor desirable within the text of this discussion to argue the relative merits of each of these theories. It is probable that none of them adequately explains every case, and equally probable that each may play some role in the composite problem of atelectasis. For practical purposes, both in prophylaxis and in therapy, each must be kept in mind as a possible source of atelectasis if the disturbance and its sequelae are to be avoided.

Clinically, the vast majority of instances of atelectasis are those of multiple areas of lobular collapse, usually confined to one side and in the lower lobe. Bilateral lower lobe atelectasis, however, is not an uncommon occurrence. Typically the disturbance manifests itself within the first forty-eight hours postoperatively with a sudden rise in temperature to 101° to 104° F. and a corresponding tachycardia. Dyspnea is not so strikingly a part of the picture as in pneumonia, nor does the patient appear grossly toxic as in the latter disease. In lobular atelectasis, unless widely disseminated, cyanosis is, at most, very mild. Examination of the chest may show some decrease in resonance over the affected lung, particularly posteriorly, and varying degrees of mediastinal shift toward the involved side are encountered. On auscultation, probably the earliest finding is a diminution in the breath sounds distributed irregularly over the involved area notably at the base of the lung. In those uncommon instances in which massive collapse of an entire lung occurs, the picture is correspondingly more dramatic. Dyspnea and mediastinal shift are prominent factors and cyanosis is more pronounced. Examination of the chest reveals inspiratory lag on the affected side, dullness to percussion over the entire collapsed lung.

and absence of breath sounds on auscultation. The startling suddenness of onset and the clear-cut physical findings, corroborated by x ray, make the diagnosis inescapable.

Treatment of this complication of operative procedures is so intricately interwoven with prophylaxis that it is impossible to discuss them separately. Preoperatively, several precautions, quite simple but nonetheless important, are observed. Unless absolutely unavoidable, patients should be up and about and not confined to bed for several days prior to operation. The reduced pulmonary expansion attendant upon bed rest is a fertile field for postoperative atelectatic collapse. Where the condition of the patient makes confinement to bed unavoidable, every effort should be made to keep him from lying in one position, particularly on the back. Turning from side to side alternately elevating and lowering the head of the bed, and sitting up for meals are among the methods of maintaining activity, even in bed which pay good dividends in the postoperative period.

Any active infection of the upper respiratory passages, including seriously infected teeth and gums, should be considered a contra-indication to elective surgery until a reasonable time after the inflammation has been eradicated. In the same vein it seems hardly necessary to stress here the vital importance of evacuation of secretions from infected portions of the lungs by adequate postural drainage before surgical procedures upon the lungs are attempted. One other item of importance, infrequently stressed, deserves emphasis. Today with the universality of the smoking habit, many patients have a long standing tracheobronchitis which is peculiarly sensitive to the irritation of tobacco smoke—the so called "cigarette cough." Elimination of smoking for several days to a week before operation will usually produce a gratifying subsidence in the irritation of the tracheobronchial tree and render the patient much less susceptible to the development of atelectasis postoperatively. Finally, here, as in other aspects of the patient's condition, proper adjustment of fluid balance is important. The dehydrated patient is more apt than not to secrete a thick tenacious type of mucus which it is difficult for the anesthetist to remove and almost impossible for the patient to cough out.

It is out of the question of course, to observe many of the foregoing precautions in the face of acute surgical emergencies. In such instances the roles of the anesthetist and surgeon at the time of operation assume, if possible, even greater significance than under less urgent circumstances. The importance of anesthesia in the prevention or development of postoperative pulmonary complications has been in the past, both over- and underemphasized. Without entering into the controversy between advocates and opponents of inhalation anesthesia, it is safe to make the broad generalization that, in the face of active upper respiratory infection, when surgery is imperative, gas oxy

gen anesthesia, either cyclopropane or nitrous oxide, is less irritating and therefore preferable to ether anesthesia, and that, other considerations being equal, noninhalation anesthesia, spinal, local or intravenous, is preferable to inhalation anesthesia.

It is our experience that the use of scopolamine as a preanesthetic drug has certain advantages. As an adjuvant to morphine it exerts a profound synergistic effect, permitting the use of smaller amounts of morphine. The hypnotic effect of scopolamine renders the patient less alert to his surroundings, less apprehensive and, consequently, more cooperative, thereby permitting smoother induction of anesthesia. It is not a safe drug for use in infancy and early childhood nor in advanced age. Under these circumstances atropine is preferable. It is argued that both drugs tend to dry the bronchial mucosa unduly, thus increasing the tendency to form viscid sputum which is conducive to atelectasis. Such, however, has not been our experience and we doubt that these drugs alone can be indicted on this score.

The use of an intratracheal tube in inhalation anesthesia is also a controversial point, one that can be settled only by large, impartial and well controlled statistical surveys. The intratracheal tube has obvious advantages and disadvantages. Its presence constitutes an irritating foreign body in the trachea which necessarily reacts, both at operation and postoperatively, by the overproduction of mucus. On the other hand, the advantages of the use of the intratracheal tube are equally obvious and to our minds outweigh its disadvantages. With the tube, aeration of the lungs is almost completely under the control of the anesthetist. Particularly in intrathoracic procedures, and in all long operative procedures, he is able periodically to inflate the lungs under positive pressure, thus preventing the tendency to collapse from developing during operation. Furthermore, the depth to which he can evacuate the tracheobronchial tree of secretions is much greater than without a tube. With a tube in place it is virtually impossible for the patient to aspirate secretions from the nose and mouth. And finally, respirations can be maintained under direct positive pressure until the patient is practically awake and the conscious effort to breathe and cough can be evoked.

More important than the type of anesthetic or method of anesthesia is the care and skill displayed by the anesthetist. When induction is smooth and anesthesia is maintained at a constant level, the patient is far less apt to have trouble postoperatively than if the anesthetist 'fights' his patient to sleep, traumatizes the oral pharynx and larynx in introducing a tube and is constantly in trouble keeping the patient anesthetized. Keeping the airways clear of secretions and a thorough evacuation by suction of the tracheobronchial tree just before the patient awakes are of far greater importance than whether or not an intratracheal tube is used.

Both the surgeon and his assistants have a responsibility equally as great as the anesthetist if postoperative pulmonary complications are to be avoided. Sharp dissection, adequate hemostasis, definitive ligation of transected vessels rather than mass tissue ligation, anatomic plane dissection where possible, protection of tissues against drying by moist sponges, minimal and gentle retraction, these represent indispensable precautions, if the danger of showers of emboli are to be avoided postoperatively. In abdominal surgery, in particular, other safeguards must be observed. Unnecessary exposure of the viscera inevitably leads to cooling and drying of these sensitive structures. Unnecessary handling of bowel by surgeon or assistants produces comparable results upon the finely adjusted autonomic innervation of these organs. Every day clinical experience has established beyond doubt that a close integration between the autonomic innervation of the lungs and that of the abdominal viscera exists and that insult to either frequently leads to injury to both.

The postoperative dressing, particularly in abdominal surgery, can also be of great significance in the subsequent condition of the patient's respiratory function. Such a dressing should not confine the costal margins, thereby reducing expansion at the bases of the lungs. On the other hand, it should be sufficiently secure so that the patient may be turned frequently with safety, and provide sufficient support to the abdominal wall so that coughing does not become an unbearable agony. In this regard, one technical point deserves emphasis. Notably in surgery of the upper abdomen, where the incidence of postoperative atelectasis is apt to be particularly high, the use of a transverse incision in preference to a longitudinal one has impressive advantages in the postoperative convalescence of the patient as well as at operation. Movement of the patient is much less restricted by pain or fear of damage to the wound, and coughing is a relatively painless procedure as compared to the extreme discomfort that coughing can cause when the operative approach has been through a vertical incision.

Postoperatively, the use of the Trendelenburg position until full consciousness returns has the advantage of providing postural drainage for secretions from both upper and lower portions of the respiratory apparatus. Thereafter, low Fowler's position is ideal for minimizing the effort necessary to cough or breathe deeply. In this clinic patients are turned hourly or every two hours during the first twenty-four hours postoperatively and no less than four times a day for the next three days. Methods of keeping the lungs expanded consist in having the patient take ten deep breaths every hour, breathing into a paper bag once an hour, and when the patient is unwilling or unable to breathe deeply, inhalations of a mixture of 5 per cent carbon dioxide and 95 per cent oxygen.

For patients in whom large amounts of mucus accumulate during or after operation, as is particularly apt to happen in association with intrathoracic procedures, active aspiration of the hypopharynx and trachea is accomplished by means of a suction machine and a long catheter passed through the nose into the trachea. The procedure is carried out as often as every fifteen minutes until consciousness returns and hourly thereafter for the first six hours postoperatively, or longer if necessary. In addition to the positive suction, this maneuver also evokes the cough reflex, forcing the patient to evacuate his own tracheobronchial tree. Properly done, it is without danger and is of inestimable advantage in preventing serious pulmonary complications. It is important to note that postoperative atelectasis is not a complication limited to patients receiving inhalation anesthesia. It occurs about as frequently following spinal, local or intravenous anesthesia as following inhalation anesthesia. Consequently, the foregoing precautions must be observed in all postoperative patients if this complication is to be avoided.

When atelectasis develops in spite of these measures, our efforts to secure re-expansion of the collapsed portions of the lungs must be redoubled, since failure to do so almost certainly results in lobular pneumonia.

In addition to the foregoing measures, a fairly definite routine, as described by Moore,<sup>3</sup> is carried out in this clinic. If not already in use, a snug binder is applied in abdominal incisions to support the wound. The patient is then dropped into the Trendelenburg position by lowering the head of the Fowler frame and raising the foot of the bed on a chair. He is then turned onto the unaffected side, and, using his free hand to support his wound, is urged to cough. Usually, this is enough to start coughing, if it is not, a sharp blow with the heel of the physician's hand upon the patient's back will frequently help. If more drastic measures are necessary, carbon dioxide-oxygen inhalations, steam inhalations with tincture of benzoin and transnasal tracheal suction are used, with the patient kept in the Trendelenburg position to secure the effect of gravity drainage upon his bronchial tree. If these methods fail to work promptly, bronchoscopic aspiration is used. It is our opinion, however, that if possible, the obstruction should be relieved by means other than bronchoscopy, since this procedure, inherently traumatic, is itself not infrequently the source of mucosal edema and oversecretion in the tracheobronchial tree.

It is not uncommon to find the tendency toward atelectatic collapse recurring once it has started. Consequently, the initial episode should be viewed as a warning to watch for recurrences in order to treat them promptly when they occur. In the event of a recurrence, or of failure to relieve the patient of his atelectasis promptly the first time, it has been our practice to start chemotherapy immediately, because



of the imminence of pneumonia. Usually this is done with sulfadiazine by mouth alone, although more recently, penicillin therapy has been used in addition to sulfadiazine, in order to be doubly sure of prophylaxis against pneumonia.

#### POSTOPERATIVE PNEUMONIA

It is improbable that pneumonia occurs as a primary postoperative complication except in rare instances. Postoperative pneumonia, usually of the lobular type, almost invariably represents a sequela of some other primary condition. The commonest sources of postoperative pneumonia are atelectasis, pulmonary infarction from peripheral emboli, cardiac failure in elderly patients, and aspiration of gastric contents. Of these, the first has already been discussed, and the second will be treated later. The third condition, circulatory insufficiency, is not, strictly speaking, a pulmonary complication, and is discussed elsewhere in this symposium.

The fourth source of postoperative pneumonia, namely, aspiration of gastric or intestinal contents, although inexcusable is, notwithstanding, an occasional catastrophe. Its occurrence indicates either ignorance of the possibility that it may happen, or carelessness in employing the simple procedures which would obviate the disaster. When operative procedures upon the gastrointestinal tract are contemplated, with the exception of appendectomy, the patient's upper alimentary tract should be prepared for at least forty-eight hours in advance, and operation should be carried out with a gastric drainage tube in place. More important still, no patient, particularly when a general anesthetic has been employed, should be removed from the operating room to his bed without the anesthetist or a physician in constant attendance. Should the patient begin to vomit in this interval, failure to provide postural drainage will inevitably result in aspiration of the vomitus. The simple expedient of elevating the foot of the stretcher and turning the patient's head to the side will obviate the possibility in all but the rarest instances. But the responsibility for this cannot be delegated to a nurse or an attendant.

If, in spite of careful prophylaxis, pneumonia does develop, the clinical picture is a typical one. The temperature rises to  $101^{\circ}$  to  $104^{\circ}$  F and maintains itself at this level. A corresponding elevation of pulse rate accompanies the temperature rise and dyspnea is usually a prominent finding. Varying degrees of cyanosis will be present and the patient is obviously toxic. A white blood count will show an increase in white cells with an absolute polymorphonuclear leucocytosis. Examination of the chest reveals dullness to percussion, diminished breath sounds and scattered fine rales over the involved areas. Therapy consists in adequate hydration, the administration of oxygen by tent, mask or intrapharyngeal catheter, and chemotherapy in the form of penicil-

lin, sulfadiazine or both. It is worthy of note at this time that where the danger of postoperative pulmonary complications is a major consideration preoperatively, as, for instance, when intrathoracic procedures are contemplated, preparation of the patient with these drugs for forty-eight hours before operation has become a routine procedure at this institution.

### POSTOPERATIVE PULMONARY INFARCTION

This topic has been treated exhaustively in another portion of this symposium, and only items relative to the care of the pulmonary condition will be discussed here. The onset of pulmonary infarction varies from the sudden overwhelming shock resulting in death almost immediately, down to minor episodes of unexplained temperature and malaise of a few days' duration. Typically the condition is manifested by sudden pain in the chest, mild shock, dyspnea and cough with the expectoration of frothy bloody sputum. It occurs most frequently one to two weeks following operation and comes as an unpleasant surprise in a patient apparently convalescing uneventfully. Examination of the chest reveals restricted movement over the involved side, dullness to percussion, usually at the base, and, on auscultation, diminished breath sounds over the same area with a friction rub if the infarction has reached the pleura. Later, rales can be heard over the involved area also. Roentgenograms taken immediately after the episode will usually reveal little, if any, change, but within forty-eight hours a wedge shaped density with the base at the pleura will be seen.

The course of pulmonary infarction may follow one of three standard patterns. It may clear without incident, pneumonia in the infarcted area and the contiguous portions of the lungs may develop, or the process may go on to abscess formation. To ward off the development of the two latter possibilities certain therapeutic measures are of value. Penicillin and sulfadiazine as chemotherapeutic agents should be started immediately. In addition the observations of de Takats<sup>4</sup> and his associates should be borne in mind. He has demonstrated experimentally that, in pulmonary infarction, not only the pulmonary and bronchial arteries, but the bronchi as well, are involved in intense and prolonged spasm. To offset this, antispasmodic drugs are of great value. In particular, papaverine and atropine are useful. We have used these in the form of Spasmalgin (Roche) administered hypodermically 1 cc every three hours with what we believe to be excellent results.

### POSTOPERATIVE PULMONARY ABSCESS

When pulmonary abscess occurs postoperatively it is most frequently either the result of aspiration of foreign material into the lungs during operation or the residual of pulmonary infarction. Both

of these conditions have been sufficiently discussed before and need no further repetition at this point.

Diagnostically an abscess of the lung may be found incidentally on roentgenography to check the progress of other pulmonary disease. More frequently, however, our attention is called to its presence by the fact that the patient has a persistent cough productive of copious amounts of purulent sputum. If the infecting organisms are the simpler aerobic pyogenes such as the pneumococci, the sputum will be comparatively odorless. But if, as frequently happens, the causative agents are the symbiotic anaerobic streptococci and staphylococci with or without associated spirochetes and fusiform bacilli, the resultant infection will be a putrid one with the production of the extremely foul fetid sputum with which we are accustomed to associate lung abscess. Physical examination at this time will reveal restricted movement of the hemithorax affected. Inasmuch as there is almost invariably about the abscess a surrounding zone of pneumonitis, percussion and auscultation over the diseased area will elicit signs of consolidation. Before the abscess is evacuated through the bronchial tree, typical findings of cavitation will be absent. At the same time the patient will manifest signs of sepsis by a spiking temperature and pulse rate, frequent chills, malaise and a marked elevation in the white count. X-ray at this time may reveal only the pneumonitis with only spotty areas of rarefaction to suggest the presence of abscess. When trans-bronchial drainage occurs, the typical signs of cavitation develop and the roentgenogram demonstrates the spherical rarefaction frequently with a fluid level present which is diagnostic of the disease. When such drainage develops, the signs of toxicity regress. The patient's temperature and pulse subside and clinically he appears much improved. Such improvement, however, can be very deceptive for unless vigorous measures are instituted promptly to eradicate the lesion, the patient rapidly develops systemic changes disproportionately severe for the apparent mildness of the pulmonary disease. These include loss of appetite, loss of weight, profound secondary anemia, fatigue, dyspnea on exertion, the joint changes known as pulmonary osteoarthropathy, and finally myeloid disease. The pulmonary lesion if untreated produces fibrosis of the adjacent lung, bronchiectatic changes in the contiguous bronchi and not infrequently additional abscesses in the same or the opposite lung. Indeed, neglected lung abscess can be a most unpleasant disease.

Therapeutically, we believe that all pulmonary abscesses deserve a reasonable period of vigorously applied conservative treatment. This means adequate chemotherapy with penicillin and sulfadiazine supplemented if organisms of the Vincent's group are present by intravenous arsenicals. Proper and thorough postural drainage three times daily is equally indispensable and we feel that bronchoscopic aspira-

tion of the abscess should be carried out twice weekly. A diet high in protein, carbohydrate and vitamins, supplementary iron therapy, and if indicated by the blood count, repeated transfusions are standard treatment in this condition. Under such a regimen the vast majority of pulmonary abscesses will begin to show improvement promptly and will be eliminated in about two months. When improvement fails to develop within six weeks, however, or when evidence of systemic toxicity persists and on x-ray the abscess appears to be advancing in spite of vigorous nonsurgical measures such conservative therapy should be abandoned and prompt transthoracic drainage of the abscess instituted. The technical details of this procedure have been exhaustingly treated in the surgical literature of the past five years and need no further elaboration here.

#### PULMONARY FAT EMBOLISM

This unfortunate complication is usually incident to the surgical lesion itself, rather than as a result of surgical intervention. It does occur occasionally, however, apparently as the result of surgery, particularly on the skeletal system, and so deserves mention here. The fundamental disturbance is the presence in the circulating venous blood of fat droplets in excess of one micron in size. These globules of fat, when they enter the finer radicles of the pulmonary circuit, plug these vessels producing a situation comparable to the classical pulmonary embolus discussed elsewhere in this symposium. With fat embolism, however, there is the added danger that the ameboid fat droplets will slowly pass through the pulmonary circulation and escape into the general circulation only to lodge elsewhere in the body, particularly in the brain, the kidneys, the liver and the heart.

The phenomenon has been seen most frequently, in the past, in association with fractures of the long bones and as a complication of orthopedic procedures. As such it was of relatively infrequent occurrence. This relationship to trauma of the skeletal system has also given rise to the theory that the circulating fat droplets originate in the marrow fat of bone and are introduced into the circulation through the open mouths of torn venous channels. More recently several observers have noted that there is a surprisingly high incidence of fat embolism in association with burns. And, while we have not as yet compiled our statistics, we, at this clinic, have been similarly impressed with the fact that severe thermal injury is not infrequently associated with fat embolism. Such an observation lends credence to the theory advanced by Lehman,<sup>3</sup> that the origin of the fat droplets resides in the blood itself, i.e., that in various injuries to susceptible individuals, there is released a demulsifying substance which dissociates blood fat allowing it to agglomerate into large droplets which constitute emboli and cause the syndrome known as fat embolism.

Clinically, this complication manifests itself any time from the day of injury or surgery until the seventh day. Its onset is quite insidious in most instances, although it may appear dramatically in the form of unconsciousness associated with a bizarre grouping of neurological signs. The more common initial findings are unexplained dyspnea and cyanosis, accompanied by or followed shortly by some disorientation or delirium. Examination of the chest may show nothing or may reveal a diffuse process suggesting early disseminated bronchopneumonia. X rays at this time usually are noncontributory, but later show diffuse opacities leading to the diagnosis of bronchopneumonia. The process may stop here, and the patient recover. More frequently the dyspnea and cyanosis increase, cerebral signs become more marked, but without clear-cut unilateral localization. Coma supervenes and the patient dies. Diagnostic criteria for fat embolism are distressingly absent. Occasionally, fat droplets can be found in the urine and in the sputum, but not with sufficient regularity to be dependable. At present, we are studying the accuracy of a rapid volumetric method for determining total blood fat content, based on the Bahecock test, as a diagnostic guide, but the data is as yet too limited to warrant drawing any conclusions. Diagnosis of this condition depends entirely upon recognition of the clinical picture plus, in the event of death, special staining techniques on autopsy material to demonstrate the presence of free fat globules in the tissues, notably the lungs, brain and kidneys.

Therapeutically, we are as yet without weapons against this complication. Maintenance of fluid balance and other general measures are used. But the only direct therapeutic attack upon the problem is the use of a dextrose alcohol mixture intravenously as suggested by Herrmann<sup>6</sup> of this clinic. And this therapeutic procedure has not unfortunately received sufficient trial to test its usefulness.

#### SUMMARY

In this brief discussion of postoperative pulmonary complications, we have endeavored to stress two principles of good surgical practice: one, that there is no substitute for detailed careful prophylaxis against the potential hazards inherent in surgery, and second, that in any major surgical procedure, the entire physical economy of the patient must be taken into consideration rather than just the local field of operation.

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## POSTOPERATIVE INFECTIONS

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INFECTIONS developing during the postoperative period may have a profound effect on mortality, morbidity and the final result of the operation. They may result in death, loss of limb or prolonged or permanent disability. Their occurrence postoperatively in individuals whose resistance is depleted by acute or chronic disease may determine the issue of life or death. The development of any infection, particularly in large wounds, almost certainly increases the period of morbidity after operation since infection, the greatest enemy of wound healing, produces further destruction of tissue and suppresses the process. Tissues destroyed by infection are usually replaced by scar tissue which may affect function as well as cosmetic appearance.

The prevention of infection in planned operative wounds represents one of the greatest achievements in surgery. In the days before Lister all operative wounds became infected and earlier surgeons felt helpless in dealing with putrefactive processes firmly established in wounds. With the application of the principles of antiseptics Lister paved the way for ultimate prevention of infections developing in clean surgical wounds. Antiseptic technic was replaced by aseptic technic and it has become possible to explore with safety the innermost cavities and recesses of the body without the development of serious postoperative infection in the great majority of instances.

### GENERAL CONSIDERATIONS

Bacteria are the cause of infection in wounds but from a practical point of view this explanation of the cause of infection is far from being satisfactory.<sup>1</sup> No method of treatment in use today leaves a contaminated wound absolutely free of bacteria and even clean surgical wounds are contaminated by airborne microorganisms. Experience has shown that bacteria may be present in a wound without producing the slightest clinical evidence of infection and that many other factors influence their development. Healthy tissues have a remarkable capacity to kill bacteria or withstand their effects, while unhealthy, irritated or devitalized tissues have limited or little powers of resistance to their action. Dead tissue in a wound invites and supports the growth of virulent organisms as well as nonvirulent or saprophytic ones.

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It is extremely important to remove any potential pabulum for bacteria and to prevent the development of a similar breeding ground during the postoperative state. Impairment of the local blood supply by damage or ligation of large vessels, displaced fractures, pressure of hematomas, tourniquets, ill applied or fitting casts, or increased sub-fascial tension due to edema or hemorrhage favors the propagation of bacteria. Suture under tension or strangulation by ligature of tissues to the wound favors the development of infection. The apposition of live tissue to live tissue after the thorough removal of all foreign, dead or dying matter promotes healing even in the face of contamination. The immobilization of soft parts as well as skeletal parts is important in the control of infection. Wounds produced by crushing and associated with heavy contamination are frequently multiple and are characterized by extensive tissue destruction, severe shock and early virulent infection. The physical condition of the patient is an important predisposing factor to infection and dehydration, shock, malnutrition, exhaustion, uncontrolled diabetes and anemia may lower his resistance sufficiently to permit bacterial invasion.

The importance of accurate diagnosis in the treatment of postoperative infection cannot be overemphasized. The determination of the site of infection, the responsible bacteria, the contributing causes and the stage of the process suggest the type of surgical therapy indicated and the effective type or types of chemotherapeutic agent. Chemotherapy, even with our extremely potent agents now available, is not a substitute for early diagnosis and adequate surgery. Although it is a very valuable adjunct.

Postoperative infections may develop in the operative wound and contiguous structures, or may develop at some distant point thereby complicating the postoperative state. They may be acute or chronic, localized, progressive, or invasive, primary or secondary, monomicrobial or polymicrobial. A brief classification of the postoperative infections to be discussed here follows.

#### I Infections of the Wound or Contiguous Structures

- A Staphylococcal
- B Streptococcal
- C Gram negative Bacillary
- D Mixed or Synergistic
- E Tetanus

- F Gas Gangrene
- G Tuberculous
- H Actinomycotic
- I Diphtheritic

#### II Remote Infections

- A Postoperative Parotitis
- B Decubitus

### I INFECTIONS OF WOUND OR CONTIGUOUS STRUCTURES

The incidence of postoperative infection in clean surgical wounds varies from 1 to 5 per cent while in wounds of violence, excluding burns, it is 16.5 to 21.7 per cent.<sup>2</sup> The most frequent postoperative infections of wounds are pyogenic, the staphylococcus being the most



common causal bacterium and the streptococcus the next. Pyogenic infections are usually secondary to contamination from sources<sup>3</sup> including the human respiratory tract, airborne bacteria laden particles of dust, unsterile dressings, instruments and utensils.

### STAPHYLOCOCCAL INFECTIONS

As a rule, staphylococcal infections tend to be localized, producing an area of cellulitis which subsequently undergoes central necrosis and abscess formation. When abscess formation occurs, the pus formed is usually thick, creamy, odorless and yellow or reddish yellow in color. Frequently, however, lymphangitis, lymphadenitis, or thrombophlebitis may complicate such infections, making them invasive. They may act as distributing foci, invade the blood stream, and produce an intermittent or constant bacteremia. Operative procedures on bones or joints may be complicated by exogenous osteomyelitis or purulent arthritis.

In the great majority of instances, the responsible staphylococcus is hemolytic, coagulates human plasma, liquefies fibrin and gelatin and is of the aureus type. Its ability to coagulate plasma is probably the best evidence of pathogenicity.

The symptoms of staphylococcal infection in closed wounds consist of swelling, redness about the margins, and increasing local pain which is throbbing in character and often synchronous with the pulse beat. The temperature may be elevated and leukocytosis is usually present. In open wounds the principal sign of infection is a purulent discharge associated with pain, redness and swelling of the wound. There may be a disproportion between elevation of temperature and pulse in infections of wounds of soft tissue. If the infection becomes invasive malaise, higher fever, lymphangitis, lymphadenitis, chills, and sweats usually develop.

**TREATMENT**—The successful management of postoperative staphylococcal infections is dependent upon early accurate diagnosis, the application of the established surgical principles of rest, heat, elevation and adequate drainage when pus has formed, and chemotherapy. Each lesion must be considered individually and treated according to its own peculiarities. Acute spreading infections are never incised or traumatized in any manner until the invasive characteristics have been overcome with rest, continuous hot fomentations, and chemotherapy. If pus or necrotic tissue is present in localized infections, their removal by adequate drainage is extremely important, for once extruded, healing usually follows promptly.

Sutured wounds showing signs of infection should first be reopened with a hemostat at the point of maximum pain, swelling or fluctuation. The opening is then enlarged to the size of the cavity, irrigated

gently with saline solution and packed open loosely with gauze. Careful dressing technic minimizes the danger of secondary infection.

Although the sulfonamides have been of very limited value in staphylococcal infections, penicillin has had a profound effect on them,<sup>4</sup> and is the chemotherapeutic agent recommended for parenteral and topical use. An adequate dose for most staphylococcal infections is 10,000 to 20,000 units administered intravenously or intramuscularly every three hours. Penicillin may also be applied topically to open lesions with brilliant results when dissolved in saline solution containing 250 to 1000 units per cubic centimeter, or in an ointment with a carbowax base. Infections in closed serous lined cavities such as meningeal, pleural, bursal and pericardial are treated effectively by local instillations of penicillin after removal of pus by aspiration.

In lesions diagnosed early and treated intensively, complete resolution may occur often without necrosis of the involved tissues. If abscesses develop, penicillin therapy alone is inadequate and must be supplemented by incision and drainage. It is recommended that penicillin therapy be started before surgery to produce a bacteriostatic concentration in the bloodstream which will inhibit the distribution and growth of bacteria invading it incident to operative manipulation. If the blood stream has already been invaded, adequate penicillin therapy usually results in its sterilization within thirty six to seventy two hours, associated with arrest of all signs of local invasiveness. The presence of devitalized tissue or other foreign bodies such as metal pins, screws or plates usually makes the effect of the chemotherapeutic agent incomplete until they are removed. We have known such processes to subside under penicillin therapy, only to recur one or more times until the foreign body was removed.

### STREPTOCOCCAL INFECTIONS

Streptococcal infections are usually secondary to contamination from human sources such as upper respiratory tract, draining infected sinuses, infected wounds, airborne bacteria laden particles of dust, contaminated instruments or dressings. The majority of streptococcal infections are produced by the aerobic hemolytic streptococcus and these tend to be invasive and to run a rather short course. The local process is usually one of cellulitis with lymphangitis and lymphadenitis and little tendency to form abscesses. When local breakdown of tissue does occur, it is characterized either by gangrene of the overlying skin or the development of thin, watery pus. Invasion of the blood stream by bacteria from this primary focus is frequent, particularly when operative intervention is made upon a pyogenic process which is locally invasive. Trauma incident to surgical intervention may cause septic thrombi to break off into the neighboring vessels and the gen-

eral circulation. The diagnosis is suggested by the presence of a locally invasive infection associated with chills, fever, rapid pulse, sweats, prostration and other signs of toxemia. It is proved by demonstrating the continued presence of bacteria in the blood by careful blood cultures.

Occasionally *surgical scarlet fever* may result from infection of a postoperative wound, and the hemolytic streptococcus is always associated with the infection. The condition is characterized by cellulitis with redness, swelling, and frequently bullous formation in and about the margins of the wound, and a typical scarlatiniform eruption which starts at the wound and spreads peripherally over the body. The rash usually occurs two to four days after the operative procedure. Scarlet fever of this type is often relatively less severe, although the local lesion may not be.

*Erysipelas*, also caused by a hemolytic streptococcus may occur in frequently in lacerated wounds about the face after an incubation period of one to three days. Ushered in by chills, high fever, rapid pulse and severe toxemia, it usually runs its course in four to eight days. It is characterized by an area of advancing cellulitis with sharply demarcated, irregular, elevated and indurated margins. The appearance of the infected skin is striking and immediately suggests the diagnosis.

**TREATMENT**—The treatment of hemolytic streptococcal infections consists primarily in the control of their invasive characteristics by rest, elevation, hot fomentations and chemotherapy, and secondarily of adequate drainage for the removal of pus and necrotic tissue when they have formed. Incisions or manipulations should never be made in streptococcal infections until the invasive characteristics have been overcome (Fig. 449) with the exception of acute hemolytic streptococcal gangrene. Infections caused by the hemolytic streptococcus respond very well to chemotherapy with either penicillin or the sulfoamides, although penicillin is the agent of choice for patients in the hospital.

In *streptococcal septicemia*, it is extremely important to diagnose the condition early and correctly to minimize the period of distribution of virulent bacteria to distant areas with the potential danger of forming metastatic abscesses. Prompt treatment is indicated with adequate general chemotherapy by sulfadiazine or penicillin and local treatment of the wound consisting of rest, elevation, hot fomentations and topically applied penicillin. If a suppurative thrombophlebitis is present in the neighborhood of the distributing infection, proximal ligation or excision should be considered. After control of the invasive characteristics of the infection under the protection of a bacteriostatic concentration of chemotherapeutic agents in the blood, drainage may be instituted when pus has formed within the wound. General supportive therapy consisting of adequate fluid and electrolytes and small

daily blood transfusions are of definite value. Frequent examinations should be made to detect metastatic infectious complications as early as possible. Each is treated according to its individual location and characteristics.

**Hemolytic Streptococcal Gangrene**—Gangrene due to the hemolytic streptococcus occasionally follows some relatively minor operative procedure or injury. The lesion is essentially an epifascial, spreading subcutaneous gangrene with thrombosis of the nutrient vessels and resultant slough of the overlying skin. It usually develops in the extremities, although the perineum, face and other parts of the body

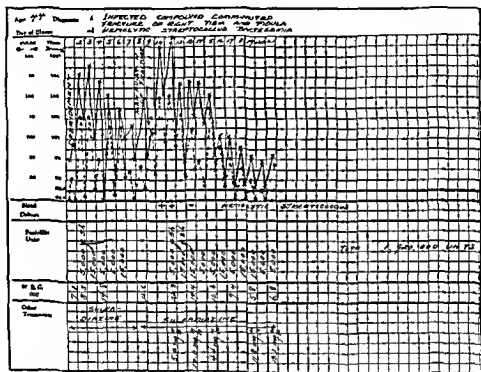


Fig 449.—Illustrating the conversion of a local hemolytic streptococcal infection in a compound fracture to a severe invasive one with bacteremia after manipulation of the bone fragments.

may be involved. It is characterized by the onset of pain and marked swelling at the site of the wound, chills, elevation of the temperature to 101° to 104° F, rapid pulse, toxemia, marked prostration, and a rapidly spreading painful cellulitis which undergoes bullous formation and a peculiar patchy and extending necrosis. Hemolytic streptococci are found in the subcutaneous gangrene and bullae, often in pure culture.

**TREATMENT**—Early recognition is imperative for a good result. Longitudinal incisions should be made as soon as possible through and beyond the gangrenous area, contrary to the usual treatment for

**streptococcal cellulitis** This is very important if the process is to be arrested After operation the wound is treated by rest, elevation, continuous compresses with Dakin's solution and removal of slough by sharp dissection without bleeding during subsequent dressings Before and after operation, penicillin or sulfadiazine should be given in adequate amounts An initial dose of 4 gm of sulfadiazine and 1 gm every four hours thereafter gives a satisfactory result A preoperative dose of 25 000 units of penicillin given intramuscularly followed by 15,000 to 20 000 units every three hours has proved effective

**Chronic Progressive Cutaneous Gangrene**—This may develop following operations for purulent infections of the chest or peritoneal cavity The condition is caused by the synergistic action of a microaerophilic nonhemolytic streptococcus and an aerobic hemolytic staphylococcus About ten to fourteen days after operation, the wound and surrounding skin become tender, red and edematous particularly about stay sutures Within a few days a carbuncular infection develops about the wound margins or stay suture holes and the central area assumes a purplish or purplish black color A wide area of bright red cellulitis develops and the central purplish spots widen, become gangrenous and finally ulcerate This results in the characteristic appearance of the lesion consisting of a central enlarging area of ulceration bordered by a purplish black narrow margin of gangrenous skin and a large area of spreading cellulitis Pain and tenderness are usually striking features particularly in the region of the purplish black margin

**TREATMENT**—This infection is slowly progressive and may ultimately cause death unless specific treatment is instituted Local excision of gangrenous margins or other conservative methods usually fail to check this process Radical excision of the lesion with the knife or cautery followed by daily applications of zinc peroxide cream or ointment and general chemotherapy with sulfadiazine or penicillin promptly arrests the infection and permits early skin grafting and healing

**Anaerobic Streptococcal Infections**—The anaerobic streptococcus may produce severe postoperative infections with or without bacteremia particularly after operative procedures upon the genital, intestinal or respiratory tracts The anaerobic streptococcus is one of the most frequent causes of septic abortions and puerperal sepsis<sup>5</sup> Postoperative peritonitis caused by the anaerobic streptococcus may occasionally complicate operative procedures upon the female genital tract such as removal or drainage of chronic active tubo ovarian abscesses<sup>6</sup> This type of peritonitis usually becomes manifest six to eight days after the operative procedure and the general signs of infection may be associated with little or no evidence of intraperitoneal infection until the process is well advanced Such conditions may be associated with anaerobic streptococcal infections of the wound and occa

sionally with metastatic abscess formation in distant regions such as the brain

An example of a severe and invasive postoperative anaerobic streptococcal infection is illustrated in the following case

G S, a 52 year old white woman, underwent normal removal of the cervix uteri and repair of cystocele and rectocele on January 5, 1944. The remainder of the uterus had been removed in 1932. On the third postoperative day the patient developed a fine rash on the back and wrists and this increased in extent and severity. The skin lesions became large, indurated, red macular, vesicular and pustular areas distributed over the entire body including the palms of the hand. Marked prostration, severe toxemia, high fever, coma and evidences of pneumonia developed. Blood cultures were positive for a nonhemolytic anaerobic

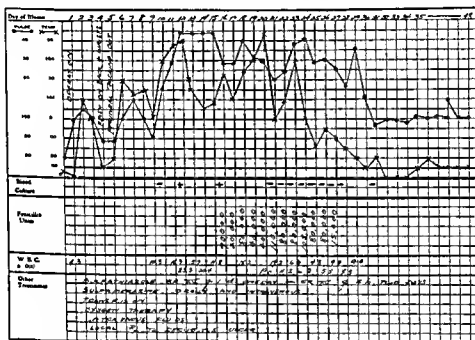


fig 450—Severe postoperative pelvic cellulitis with anaerobic streptococcus septicemia treated successfully by penicillin

streptococcus. The administration of sulfathiazole and sulfamerazine produced no evidence of improvement. A good but somewhat delayed response to penicillin given by continuous intravenous drip occurred and the patient made a complete recovery (Fig 450).

**TREATMENT**—Infections produced by the anaerobic streptococcus are usually susceptible to penicillin but not to the sulfonamides. Accordingly, in addition to the usual methods of treating infected wounds already described, early and adequate therapy with penicillin is indicated. The management of postoperative peritonitis caused by the anaerobic streptococcus is difficult and the diagnosis may be uncertain. Treatment consists principally of general supportive measures and chemotherapy with penicillin.

**Postanginal Sepsis**—Postanginal sepsis<sup>7</sup> may rarely occur after operations on the oral, nasal or pharyngeal cavities. It is often caused by a hemolytic streptococcus or an anaerobic streptococcus and is characterized by the development of septic thrombophlebitis of the internal jugular vein, septicemia, metastatic abscess particularly in the lung, and terminal cerebral thrombophlebitis with meningitis. The condition may follow such operations as tonsillectomy, drainage of a peritonsillar abscess, or surgical procedures upon a nasal sinus. Its onset seven to ten days after operation is sudden, with hard shaking chills and high fever of the septic type. Cellulitis, pain and induration are evident in the region of the operative area and in the neck along the course of the internal jugular vein and sternocleidomastoid muscle. Careful blood cultures reveal the presence of the causal organism.

**TREATMENT**—This condition has a very high mortality rate and is fatal unless the diagnosis is made early, operative ligation or removal of the internal jugular vein is performed, and adequate chemotherapy with sulfadiazine and penicillin is instituted. Vigilance is necessary to detect the presence of metastatic abscesses requiring drainage or topical administration of penicillin.

#### GRAM NEGATIVE BACILLARY INFECTIONS

Pure infections caused by gram-negative bacilli of the intestinal group are infrequent in postoperative wounds. At times, however, local wound infections occur after operations upon the intestinal tract which are produced by *B. coli*, *B. typhosus*, *B. pyocyaneus* or other bacteria of this group in pure culture.

Gram negative bacillary infections of open postoperative wounds may be the result of secondary contamination. *Bacillus pyocyaneus* infection is a typical example. Under ordinary circumstances *B. pyocyaneus* is relatively nonpathogenic but under conditions of general debility or the presence of dead tissue within a wound, it may produce local and occasionally general infection. Its presence increases the proteolytic destruction of tissue, delays healing and favors chronic suppuration. Lesions produced by the colon bacillus in wounds may be very acute and intense, but in general they are mild and tend to become chronic. Occasionally, such wound infections may have produced considerable immunity to the causal bacteria through earlier attacks. A local wound infection may become manifest as an abscess many months or a year after the operative procedure.

**E. T.** a 40 year old white woman underwent a cholecystectomy for gall bladder disease on March 25, 1944. The gallbladder was found to be dilated to five times its normal size and filled with thick brown bile. Her postoperative course was not remarkable and she was discharged on April 7, 1944. During the following months she complained of tenderness and a small mass developed in her incision which was observed by her physician on October 5, 1944. This

swelling in the center of the incision became larger and definitely tender. Physical examination showed a fairly well developed, well nourished woman who did not seem to be in any discomfort. Her temperature was 100, pulse 86, blood pressure 110/70 and white blood count 7800. In the center of an upper right hockey stick incision a small nodule  $1\frac{1}{2}$  cm in diameter was palpable. The mass was tender and firm and the overlying skin was red and slightly edematous. Pelvic examination was essentially negative.

The patient was readmitted to the hospital and under local anesthesia a 3 cm incision was made through the center portion of the old scar. An abscess cavity filled with thick gray pus and lined with a thin gray sac was found lying in the scar just deep to the subcutaneous fat. The cavity was opened widely and drained thoroughly. Cultures of the pus showed the presence of *B. typhosus* in pure culture. Daily application of tyrothricin ointment to the wound surfaces was followed by rapid control of the infection and healing.

**TREATMENT**—Treatment of pure gram negative bacillary infections of postoperative wounds consists of adequate drainage, local management of the wound with heat, rest and topical application of Dakin's solution, and general chemotherapy with sulfadiazine. Penicillin is of little or no value in this type of infection. When streptomycin becomes more available it will undoubtedly be of considerable value in the management of gram negative bacillary infections. The removal by sharp dissection of all necrotic tissue from these infected lesions is of great help in their control.

**Surgical Diphtheria**—Postoperative wounds occasionally become infected by the Klebs-Löffler bacillus, and the infection may be manifest locally by an acute ulceration and cellulitis with infiltration of the skin and subcutaneous tissues about the wound or by chronic indolent ulceration of an open wound which fails to heal. The diagnosis is suggested by the appearance of the lesion with a false membrane which bleeds when its removal is attempted. The diagnosis is proved by recovering the organism in cultures from the wound and proving its virulence with inoculation in guinea pigs.

**TREATMENT** consists of isolation of the patient, local hot compresses to the wound, the administration of diphtheria antitoxin and the general administration of penicillin.

#### MIXED OR SYNERGISTIC INFECTIONS

There is a large group of infections which complicate elective or emergency operations upon the hollow organs of the gastrointestinal, respiratory and genito urinary tracts. It is a miscellaneous group with a polymicrobial etiology consisting usually of a mixture of aerobic and anaerobic gram negative bacilli of the intestinal group and gram positive cocci and bacilli. The symbiosis of aerobes and anaerobes and their resultant synergistic action determines to a large extent the characteristic nature of these infections.<sup>8</sup> Among the aerobes recovered from such infections are *B. coli*, *B. proteus*, *B. alcaligenes*, *A. aero-*



genes, *B. pyocyaneus*, streptococci, diphtheroid bacilli and staphylococci. Among the anaerobes are *B. melaninogenicum*, anaerobic streptococci, *B. theroides*, *B. fragilis* and members of the clostridial group.<sup>9</sup> They are characterized by the development of slough in the subcutaneous tissue, fascia, retroperitoneal tissue and areolar tissue of the intermuscular planes. If the process is unchecked, it spreads through the tissue planes mentioned, producing thrombosis of the neighboring vessels, abscess formation and finally extensive gangrene of the overlying skin. Examples of postoperative mixed infections are deep infections of the neck, human bite infections, postoperative peritonitis, phlegmonous cellulitis of the abdominal wall, and putrid empyema.

**Deep Abscesses or Spreading Cellulitis of the Neck**—These are likely to develop after operative procedures in or into the oral or pharyngeal cavities. The great majority of deep cervical infections still arise from operative procedures upon infected teeth and tonsils, lacerations of the mouth and compound fractures of the mandible, although they may complicate the removal of a thyroglossal duct cyst or an esophageal diverticulum. Penetrating wounds of the neck and perforation of the pharynx by foreign bodies or endoscopic examination may also be precipitating causes. The importance of fascial planes in the spread, diagnosis and treatment of these infections is well established. Fascial planes form well limited compartments and infection confined within them may so disguise the usual signs associated with the accumulation of pus that the diagnosis may be delayed beyond the optimum time for decompression and drainage. Sufficient pressure may develop to obstruct respiration or to cause spread of the infection into the mediastinum. Although the streptococcus is associated with the majority of these abscesses, it is usually present in association with the *B. melaninogenicum*, staphylococcus, the anaerobic or microaerophilic streptococcus or one or more gram negative bacilli.

**TREATMENT**—The successful management depends primarily upon early diagnosis and adequate early drainage. The presence of pain and marked swelling of the neck complicating injuries or operative procedures of the mouth or neck are the greatest aids in making the diagnosis. Fluctuation is rarely encountered unless the pus breaks through the dense fascial barriers into the subcutaneous tissue. The development of fluctuation as a sign of pus should not be waited for, as extension of the process or death may precede it, as for example in Ludwig's angina. Roentgenograms for soft tissue detail may show the presence of gaseous infiltration and indicate the presence of a crepitant cellulitis. Blind incision over swollen areas may be dangerous or inadequate. Every effort should be made to localize the infection within definite anatomical spaces, and then decompress that area by adequate incision. The wound after operation is treated by local dressings, gentle irrigations, and the excision by sharp dissection of all ob-

viously devitalized tissue. Other therapy as indicated in the individual case may consist of general supportive measures, oxygen, and chemotherapy with sulfadiazine and penicillin. The necessity for tracheotomy may arise.

**Human Bite Infections**—Severe infections with marked morbidity may complicate wounds produced by human bites. The infection usually occurs when a human being voluntarily bites another or strikes a blow with the hand, which is cut by the teeth of the intended victim. The wound is usually a puncture wound of considerable depth through skin, subcutaneous tissues, various fascial planes, tendons, and often into a joint. Since the wound is made with a relatively dull object, contusion of the tissues occurs and supports the growth of the heavy contamination by mouth organisms to produce severe infections. A mixture of bacteria is usually found consisting of aerobic nonhemolytic streptococci, anaerobic streptococci, *B. melaninogenicum*, spirochetes and staphylococci. Although spirochetes are never found alone in these infections, they are associated with the more severe ones. When fresh human bite wounds are treated by limited or inadequate surgical measures, evidence of inflammation around the bite appears within the first one to three days after injury and progresses steadily thereafter. The part becomes swollen, red, painful and useless. Fever is usually moderate but may be as high as  $105^{\circ}\text{F}$ . Systemic reaction is occasionally profound, and the appearance of the local infection soon becomes alarming. Granulation tissue forming within the wound becomes shaggy, gray, cyanotic and edematous, and exudes a thick, foul, purulent material. There is extensive progressive necrosis of tissue, particularly of the areolar tissue. Burrowing into the deeper soft tissue spaces as well as the joints is characteristic of the infection.

**TREATMENT**—The prevention of infections of this type is the most effective form of treatment. Radical excision of the wound, as soon as the patient is seen, followed by zinc peroxide dressings incorporating a splint for immobilization, and combined general sulfadiazine and penicillin therapy is the most effective means of preventing human bite infections. When tendons are severed in human bite wounds, primary tenorrhaphy should not be attempted. When infection has already gained a foothold, most surgeons agree that any temporizing measure is unsuccessful. Radical decompression of the infected area and tissue planes is extremely important, and as complete a debridement of the involved tissue as possible is done, followed by the topical daily application of zinc peroxide dressings. Zinc peroxide may be used as a thick, creamy suspension in distilled water or as an ointment in carbowax.<sup>10</sup> Wounds are then covered with absorbent cotton saturated in physiological saline solution and sealed over by gauze impregnated with petrolatum to prevent evaporation and drying. General chemo-

therapy with sulfadiazine and penicillin are valuable adjuncts to adequate surgical management.

**Postoperative Peritonitis.**—Postoperative peritonitis is usually a polymicrobial disease secondary to operative procedures on the gastrointestinal tract.<sup>11</sup> The normal peritoneum possesses surprising natural powers of resistance to infection and it is difficult to produce fatal peritonitis in experimental animals with pure cultures of those bacteria usually found associated with peritonitis unless excessive amounts of the culture are used. All the evidence points to the fact that the mere presence of single strains of bacteria in the healthy peritoneal cavity usually fails to cause peritonitis in the absence of devitalized tissue. There are additional factors necessary for the development of peritonitis in the presence of contamination. If the peritoneum is injured or devitalized by irritants, ligatures, foreign bodies, gastrointestinal enzymes, bacterial toxins or trauma, infection will occur in the presence of contamination. If repeated or constant soiling occurs such as that produced by an unrepaired perforation of the intestine or a leaking anastomotic suture line, the peritoneum is unable to withstand bacterial attack. Another very important factor in the production of secondary peritonitis is the synergistic<sup>8</sup> or cumulative action of the numerous intestinal bacteria growing in symbiosis.

The diagnosis of postoperative peritonitis often is extremely difficult. Signs of severe infection with rising temperature, pulse and respiratory rates and prostration on the third to fifth day after operation suggest the presence of this complication, but there may be none of the other signs usually associated with preoperative peritonitis until the disease is well advanced. If diffuse tenderness, muscle spasm, distention and vomiting are present, the diagnosis is relatively simple. Associated with the elevation of temperature, pulse, respiration rates, leukocytosis and other signs of general infection may be cyanosis and an unexplained fall in blood pressure on the second or third day after operation.

**Treatment.**—In addition to being difficult to diagnose, established postoperative peritonitis is frequently difficult to control and may result in death. Its prevention is the most effective form of treatment. This can be done by early diagnosis of inflammatory intra-abdominal lesions, good surgery, adequate preoperative preparation and chemotherapy. Injury or devitalization of the intraperitoneal tissues is reduced to a minimum by gentle handling of the intestines and peritoneum, avoidance of strangulation of tissue by ligature, sharp dissection whenever possible and careful preservation of the intestinal blood supply. The avoidance or reduction to a minimum of bacterial contamination of the peritoneum is principally a matter of operative skill, particularly in intestinal resections and anastomoses. The danger of peritonitis developing after intestinal resections in the presence of ob-

struction is well recognized unless a preliminary decompression is done. There are many intra-abdominal lesions, however, in which the bacteria have extended beyond the wall of the viscus into the adjacent tissues before the operation is undertaken. Under such conditions, treatment is directed toward the control of this infection. Preoperatively, signs of dehydration or toxemia indicate the need for administration of parenteral fluids, blood and electrolytes. The instillation of 5 gm of sulfanilamide powder within the peritoneal cavity in the presence of contamination seems to be a worthwhile procedure. In the presence of established infection, however, there is considerable doubt in my mind as to its efficacy. General chemotherapy with sulfadiazine, we believe to be of distinct value in the control of this condition. Postoperatively, the use of Fowler's position, continuous gastric suction, interval doses of morphine and repeated blood transfusions are important. Fluids by mouth are restricted until peristalsis has been reestablished. The adequacy of peristalsis is proved by clamping off the indwelling gastric tube and permitting the patient to drink water for six to eight hours in 1 ounce amounts. If aspiration of the stomach at the end of this time yields less than 70 cc of fluid it is an indication that the peristalsis is adequate.

In established postoperative peritonitis, the treatment is conservative. One source of toxemia in peritonitis is the accumulated fluid in the distended loops of bowel. Continuous suction by Wangenstein's method through an indwelling gastric or duodenal catheter removes most of this fluid, puts the intestinal tract at rest, contributes to the patient's comfort, prevents devitalization and secondary perforation of the intestines from prolonged overdistention, reduces the incidence of pulmonary complications, and lowers mortality. Fluids by mouth are withheld and interval doses of morphine aid in maintaining the intestinal tone. In addition to being more comfortable, Fowler's position favors the intra-abdominal drainage to the pelvis where abscesses, if they do develop, can be treated more satisfactorily. Massive distention of the abdomen may add to the patient's comfort.

General supportive therapy, very important in combating the effects of postoperative peritonitis, includes small daily blood transfusions, the administration of parenteral fluids to maintain positive fluid and electrolyte balances, the use of continuous oxygen, and chemotherapy. Sulfadiazine should be given parenterally, under the usual method of control, early in the infection by the subcutaneous or intravenous administration of 3 gm of sodium sulfadiazine every twelve hours to maintain a blood level of 6 to 10 mg per 100 cc. Penicillin may also be administered intramuscularly or intravenously in amounts of 15,000 to 20,000 units every three hours. Vigilance is necessary to detect presence of developing abscesses which must then be treated as indicated.

**Phlegmonous Retroperitoneal Cellulitis**—A phlegmonous type of retroperitoneal cellulitis may complicate operations upon the lower intestinal tract and usually becomes manifest on the fifth to seventh day. It is characterized by a spreading cellulitis of the retroperitoneal areolar tissues, by production of considerable slough and necrotic membrane, by thrombosis of the adjacent vessels, and by profound toxemia with unexplained fall in the blood pressure. Although this is often referred to as "anaerobic cellulitis," we believe it is caused by the synergistic action of the group of aerobic and anaerobic bacteria resident in the intestinal tract at the time of the operation or injury.

The diagnosis is difficult in the early stages of the infection. Development of severe signs of infection and unexplained drop in blood pressure may suggest the presence of the condition but not establish it. If the process spreads to the inguinal region or the flank, the diagnosis may become easy through the development of the edema redness, and the discoloration of the skin often with the development of bullae filled with discolored blood.

H. D. A., a 75 year old man was admitted to the hospital on November 11, 1943 with a carcinoma of the rectum. His general condition was good and he appeared to be ten years younger than his age. On rectal examination a soft pedunculated mass about the size of an egg was felt.

A combined abdominoperineal resection for adenocarcinoma of the rectum was performed. The patient was given 10 g. of sulfadiazine orally every 4 hours. On the eighth postoperative day he had a chill followed by a temperature of 102.5° F. On the ninth postoperative day it became apparent that he had a rapidly spreading retroperitoneal infection which involved the perineal wound, the pelvic floor, the retroperitoneal tissues and the flank. He developed profound toxemia, went rapidly downhill and died on the ninth day after operation. At the time of death the entire left side of the body, especially the left flank, left axilla and left supraclavicular space was involved in a crepitant hemorrhagic gangrenous cellulitis (Fig. 451).

**TREATMENT**—Prevention of this condition is the most effective form of treatment and may be accomplished most satisfactorily in traumatic wounds of the abdomen associated with contamination of the retroperitoneal space by adequate retroperitoneal drainage after closing the peritoneal defect. In elective operative wounds on the lower intestinal tract, covering the denuded areas with peritoneum and local and general chemotherapy with sulfonamides is usually adequate. Occasionally, the administration of sulfadiazine may attenuate or suppress the development of the infection until after the discontinuance of chemotherapy. Instances of severe fulminating infections developing within two days after cessation of chemotherapy and milder infections occurring three to six weeks after the discontinuance of sulfadiazine therapy have been seen at this clinic.

If retroperitoneal infection has occurred, recognition of the process and decompression by radical incision and drainage is extremely important. Effective drainage may be accomplished by way of the flank, inguinal region or suprapubic area according to the location of the process. General chemotherapy with sulfadiazine and penicillin aids in the control of the invasiveness of this infection. Removal of obvious devitalized tissue or slough by sharp dissection is indicated at subsequent dressings (Fig 452)



Fig 451 Severe postoperative retroperitoneal cellulitis following combined abdominal perineal resection

**Infection of Abdominal Operative Wounds**—This same group of organisms may cause infection of abdominal operative wounds. It is minimized by sharp dissection, protection of the wound edges, the use of gauze during the operative procedure, burial of a minimum amount of sutures, and closure of heavily contaminated wounds with silver-wire sutures through all layers, according to the method advocated by Reid, Zininger and Merrill.<sup>12</sup> If a wound infection develops, it usually becomes manifest within five to seven days by local swelling, pain, redness, fever and leukocytosis.

**TREATMENT**—The infection is controlled very satisfactorily by early



Fig 452—A Extensive necrotizing mixed infection of perineum and thigh secondary to retroperitoneal phlegmon immediately after radical incision and drainage B Clean appearance of wound one week later after daily dressings with zinc peroxide calcium peroxide ointment

of the infection and destruction

and area by incision and  
 noting further spread  
 of chemotherapy with

sulfadiazine and penicillin removal of obviously devitalized tissue or slough which invites or supports bacterial growth and the topical application of zinc peroxide calcium peroxide ointment dressings

Chemotherapy has aided in the control of the invasive qualities of the infection but has not replaced in any sense the principle of early and adequate surgical drainage

**Infection of the Pleural Cavity Complicating Penetrating Wounds of the Diaphragm**—A severe and difficult to control mixed infection of the pleural cavity may complicate combined penetrating wounds of the chest and abdomen with perforation of the esophagus stomach or intestine. It is characterized by progressive effusion of thin bloody purulent fluid within the pleural cavity and signs of profound toxemia with high fever rapid pulse increased respiratory rate leukocytosis prostration and often a fall of the blood pressure which may begin on the first to third day after injury or operation. The bacteria usually found infecting the pleural cavity consist of a mixture of the intestinal organisms including *B. coli* or other gram negative bacilli streptococci staphylococci and various anaerobes such as *B. melanogenicum* anaerobic streptococci and clostridia. Signs of pleural effusion such as dullness altered breath sounds and displacement of the mediastinum may suggest the presence of this complication and are indications for diagnostic thorocentesis which proves the diagnosis. Roentgenograms necessarily taken by a portable machine have been of relatively little practical value since the rapid respirations of a desperately ill uncooperative patient prevent clarity.

**TREATMENT**—We have found that prevention of this complication is the most satisfactory form of treatment. Early closure by suture of all penetrating wounds of the diaphragm is imperative to minimize the degree and period of contamination of the pleural cavity by intestinal contents. The use of general sulfadiazine therapy along with closure of the perforating wounds is of value in its prevention or attenuation. If infection does develop after the above measures it has been our experience that usually it can be controlled by aspiration of the fluid and instillation of a solution of 100 000 units of penicillin in physiological saline every twenty four hours for three or four days. If the penetrating wound of the diaphragm is not sutured a severe pleural infection may develop in spite of general sulfadiazine therapy which may be fulminating and very difficult to control. Once the infection is established the recommended treatment consists of closed thorotomy with insertion of a catheter for continuous drainage and decompression of the pleural cavity general supportive measures including oxygen therapy and adequate chemotherapy with sulfadiazine and penicillin.



## TETANUS

Tetanus may complicate civilian wounds and is a dreaded post operative condition. Compound fractures, wounds produced by blank cartridges fired at close range, burns, and puncture wounds of the extremities, particularly those with embedded splinters or other foreign bodies, are frequent forerunners of tetanus. Insect bites, hypodermic injections and chronic ulcerating wounds have also been known to be sources. Concomitant necrosis of tissue incident to trauma, irritation by a foreign body, or an associated pyogenic infection facilitates the growth of *Clostridium tetani* and the development of infection.

Tetanus is essentially a wound infection caused by *Clostridium tetani* with the liberation of a potent water soluble toxin which diffuses through the adjacent skeletal muscles and acts on the neuromuscular end organs to cause a state of tonic contraction (local tetanus) and which is distributed by the circulating blood or lymph to susceptible cells in the cord, medulla and motor end organs of the skeletal muscles to produce trismus, risus sardonicus, opisthotonos, rigidity of the abdominal muscles, spasm of the skeletal muscle of the extremities, painful generalized clonic convulsions precipitated by external stimuli and interference with the respiratory mechanism (generalized tetanus). Associated with the disease are the usual signs of infection including fever, tachycardia and moderate leukocytosis. The mortality rate is still high, being 50 to 60 per cent in established generalized tetanus. The outcome is already determined in most instances when the patient is first seen by the surgeon.<sup>13</sup> No form of treatment will prevent a fatal outcome in many patients, while in some others spontaneous recovery will occur without specific therapy. In the third group the outcome of life or death is determined by the surgeon's ability to diagnose promptly and treat adequately. This is particularly so during the prodromal period. The length of the incubation period, however, is a more reliable prognostic aid. If it is less than seven days, the mortality rate is extremely high, but if it is greater than seven days, it becomes increasingly less.

Death is usually due to respiratory arrest occurring during a convulsion, to asphyxia, to an exhausting toxemia, or to poisoning by barbiturates used to control the convulsive seizures. The diagnosis of tetanus is usually not difficult, particularly when the disease is seen in the third stage or period of convulsions. The difficulty comes in making the diagnosis during the prodromal period when early treatment offers the best prognosis. The history of a puncture wound and the typical clinical picture make possible a presumptive diagnosis which is proved by demonstrating the causal agent in pus by smear or culture and by the further course of the disease.

The following case is an example of postoperative tetanus developing after an elective operative procedure

A L D, a white girl  $2\frac{1}{2}$  years of age, had extensive contractures and keloid formation of the hand which resulted from a wringer injury five months previously Six weeks prior to admission, a pedicle graft was made on her anterior abdominal wall and two weeks before admission, the graft was transferred to the left hand She remained well until two days before admission, when she developed fever, restlessness difficulty in opening her mouth, and spasticity of the extremities

Examination revealed an acutely ill child with opisthotonos, risus sardonius, frequent clonic convulsions, and areas of infected gangrene at the graft and donor sites Cultures from both areas were positive for *Cl tetani*

Treatment was started immediately with antitetanic serum, penicillin, sedation with sodium amytal, and general supportive therapy The seizures were only partially controlled, her temperature rose to  $106^{\circ}$  F, and she died suddenly in respiratory arrest twenty four hours after admission

**TREATMENT**—The most effective treatment of tetanus is its prevention through passive immunization at the time of injury with prophylactic injection of 1500 or more units of antitetanic serum or by active immunization produced by a series of tetanus alum-precipitated toxoid injections given subcutaneously months before injury A booster dose of toxoid at the time of injury is desirable

The main objectives in the management of established tetanus are the prevention of additional toxin from reaching the central nervous system, the removal of the source of toxin, and the adequate sedation of the patient for control of the convulsions To neutralize the circulating toxin, an initial intravenous dose of 50,000 units of antitetanic serum often followed by 40,000 units injected intramuscularly may be given after a negative skin test Globulin modified serum is used to decrease the incidence and severity of serum reaction An additional 10,000 to 20,000 units may be injected about the wound which is excised one hour later The resultant wound may be packed open with zinc peroxide-calcium peroxide ointment, and the dressings are changed daily An additional intrathecal injection of 15,000 to 20,000 units of antitetanic serum may be administered by a lumbar puncture

The control of convulsive seizures in tetanus is a difficult problem If sufficient amounts of barbiturates are administered to control them death may occur from barbiturate poisoning Rectally administered paraldehyde is much safer but may be inadequate The administration of sodium pentothal is a satisfactory way of controlling the convulsive seizures and the tonic spasm, but excessive and toxic amounts may be required over a four or more day period The fluid and electrolyte balances are maintained by supportive intravenous therapy Gavage may also be of value It is important to keep the patient in a dark, quiet room where the number of external stimuli can be reduced to a minimum

## GAS GANGRENE

Gas gangrene is a clinical entity of multiple bacterial etiology. It is a mixed infection principally involving muscle and characterized by spreading infectious crepitant gas gangrene. Gas gangrene is a relatively rare disease occurring in only 0.5 to 2.0 per cent of all war wounds and less frequently in severe civilian wounds. Mullally<sup>24</sup> pointed out that infection by gas forming anaerobes is a common feature of all war wounds and that gas gangrene is an infrequent complication of such infection. It is more common in compound fractures than in soft tissue wounds. A great variety of gas producing anaerobic bacteria, chiefly the *Cl. welchii*, *Cl. sporogenes*, *Cl. oedematiens*, *Cl. histolyticus* and *Vibrio septique* have been repeatedly found in association with this condition. The individual case usually presents a mixed bacterial flora of aerobes as well as anaerobes, and the clinical picture varies with their combined characteristic activities. Many forms of clostridial infection of wounds are recognized and have been classified according to etiology and pathologic morphology. The infection may remain strictly confined within the muscle or may tend to spread and involve a single group or entire limb of the body. With certain bacteria a gaseous infiltration and edema may develop with others, edema without gas, and with others, rapid digestion and dissolution of tissue with moderate edema but no gas. Most frequently the dominance is only partial, and gaseous infiltration, edema and rapid tissue destruction exist in the same wound with profound intoxication. In infection of deep wounds the production of gas and edema increases the pressure beneath the deep fascia and acts as an expanding tourniquet favoring further devitalization of muscle by the compression of smaller vessels and upward spread of the infection through the tissue planes. The muscles with impaired blood supply become soft, mushy and dark red in color. There is an excessive amount of fluid in the area which tends to escape through the wound as a brown, watery, foul smelling discharge containing many bacteria but a paucity of leukocytic cells.

The exciting factors of gas gangrene are not well understood at the present moment. Wounds containing a large amount of devitalized torn, contaminated muscle are prone to develop this type of infection, but do so relatively infrequently. The specific factor which determines whether or not gas gangrene develops in a wound in the presence of clostridial contamination is unknown.

The early diagnosis of gas gangrene is difficult. It may be unrecognized until the lesion is far advanced, since wounds prone to develop gas gangrene are extensive ones and their treatment requires the use of large dressings, casts or splints, which make observations indirect and deductions difficult and uncertain as to the progress of events within the wound. Once the lesion is sufficiently established to permit

a diagnosis from the clinical appearance, a far advanced and often irreversible process is present. Earlier diagnosis is possible by the recognition of the presence of *Cl. welchii*<sup>15</sup> and the demonstration of spreading gaseous infiltration of muscle by serial roentgenograms.

**TREATMENT**—The prevention and successful management depend primarily upon good surgery, as the prophylactic use of gas gangrene antiserum and chemotherapy has been disappointing. Surgical treatment of established clostridial infections varies with the stage and extent of the process. If the diagnosis is made early while the process is more or less localized and in the incipient stage, radical decompression of the involved fascial compartments with excision of the involved muscle usually will arrest the process and save the extremity. If the diagnosis is made late when the process is extensive and has caused irreversible gangrenous changes in the extremity, open amputation of the guillotine type or some modification is necessary. The open wounds are put at rest, elevated, and treated topically with dressings of zinc peroxide calcium peroxide ointment changed every twenty-four to forty-eight hours. Chemotherapy with sulfonamides and particularly penicillin are valuable adjuncts to surgery, and the use of adequate amounts of specific antitoxin aids somewhat in controlling the profound toxemia. Daily blood transfusions should be given for correction of the profound anemia which frequently is associated with this condition and for general supportive effect. Adequate administration of fluids and electrolytes is indicated to correct acidosis and toxemia.

#### TUBERCULOUS INFECTIONS OF WOUNDS

Postoperative wounds may occasionally become infected by the tubercle bacillus, particularly following operations upon known or unknown tuberculous lesions. The infection may be manifest as a cold abscess, one or more chronically draining sinuses, an indolent ulceration, or a granulomatous lesion with ulceration. The diagnosis is suggested by the appearance of the lesion and proven by biopsy or demonstration of the organism by smear, culture or animal inoculation. Treatment consists of the usual therapy for tuberculosis. In selected instances, surgical excision of the entire process, particularly if bone is involved, offers the best chance of cure. As yet chemotherapy has been of no practical value.

#### ACTINOMYCOTIC INFECTION

An infection caused by the *Actinomyces bovis* develops in wounds made in the presence of deep seated actinomycosis such as ileocecal or thoracic lesions. It is characterized by the development of a chronic, stony hard granulomatous mass which subsequently breaks down to

form central abscesses and multiple sinuses discharging a peculiar seropurulent fluid containing "sulfur" granules (Fig 453). The tumor becomes adherent to the overlying skin, which then assumes a bronze or purplish red color. The diagnosis is suggested by the appearance of the lesion and proven by the demonstration of the ray fungus in the pus or biopsied material by microscopic examination or culture.

**TREATMENT**—The lesions may be very resistant to therapy. X-ray therapy and the administration of sulfonamides over a period of several months have been of definite value in some forms of actinomycosis.



Fig 453—Postoperative actinomycotic infection of McBurney appendectomy wound

sis, but have been of very limited value in wound infections complicating the thoracic and abdominal types. Penicillin given over a period of four to eight weeks has been much more effective, in our experience producing a decrease in the size of the tumor, amount of discharge and severity of the pain. Although it has arrested this type of infection, it has failed to cure any in our experience.

## II REMOTE POSTOPERATIVE INFECTIONS

Many infections may develop during the postoperative state in tissues or organs remote from the region of the operative wound. Pulmonary and urinary tract infections are frequent examples and will

be discussed elsewhere. Two examples chosen for discussion here are postoperative parotitis and decubitus.

**Acute Pyogenic or Secondary Parotitis.**—An acute pyogenic parotitis may occur during the postoperative state of approximately 0.5 per cent of all patients undergoing major surgery. It is most frequently seen in older patients debilitated by infection or some associated metabolic disease such as cirrhosis or nephritis. Drying of the oral mucous membrane caused by dehydration, mouth breathing and reflex suppression of salivary secretion aids its development. The process is usually secondary to extension of infection from the mouth by way of Stensen's duct. The staphylococcus is the most common etiologic agent, although the streptococcus, pneumococcus and occasionally *B. coli* may be.

The onset is usually sudden with marked pain and tenderness over the region of the involved gland followed by chills, high fever, toxemia and progressive swelling of the gland with displacement of the lobe of the ear and reddish discoloration of the overlying skin. The associated cellulitis may spread to involve the neck, eye, forehead and lateral aspect of the nose. The complication is usually unilateral, although both sides may be involved at the same time or successively.

**TREATMENT.**—To prevent postoperative parotitis, careful preoperative and postoperative oral hygiene, prevention of dehydration, and preservation of salivary excretion by chewing are necessary. If the condition does develop, conservative management with massive hot fomentations, adequate fluid and electrolyte intake, and chemotherapy with Lugol's solution<sup>16</sup> or penicillin is very effective. Incision and drainage is no longer practiced at this clinic unless definite abscesses develop, and treatment by x-ray or radium irradiation has been replaced by Lugol's solution or penicillin. The administration of Lugol's solution has been very effective in our experience, 150 to 200 minims being administered daily by hypodermoclysis or mouth until improvement occurs. Thereafter the dose is gradually decreased. With this form of therapy, improvement begins after forty-eight hours and results in complete resolution of the infection within seven to ten days. Penicillin may also be used effectively, giving 15,000 to 20,000 units parenterally every three hours.

**Decubital Ulcer.**—"Bed sore" may occur during the postoperative state as the result of bacterial invasion of tissue devitalized by local circulatory impairment produced by the pressure of the body. It is always a serious complication because of its effect on morbidity and mortality. In patients who are debilitated, bedridden, and unable to move about in bed, areas of pressure necrosis are apt to develop in the soft tissues caught between bony prominences and the underlying bed. Decubiti are prone to develop in the region of the buttocks, perineum, or lower extremities where skin contamination is heavy and infection

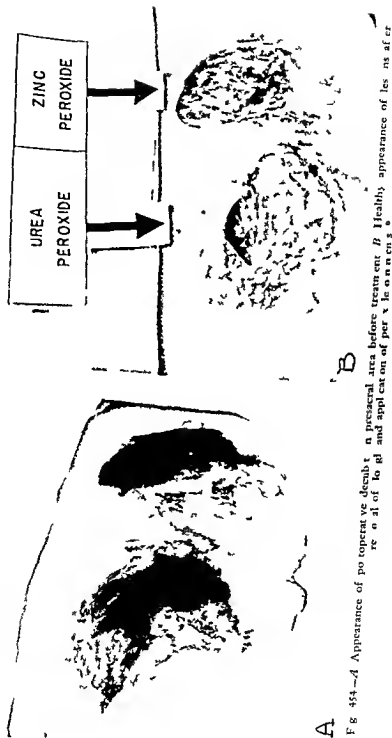


Fig. 454.—A Appearance of postoperative decubital ulcers on the sacral area before treatment B Healthy appearance of lesions after application of Urea Peroxide and Zinc Peroxide

of the devitalized tissue inevitable. The infection in turn usually produces further liquefaction and necrosis of tissue with burrowing and undermining (Fig 454).

**TREATMENT**—Attempts should always be made to prevent the development of this complication by improving the patient's general condition, by adequate nursing care consisting of changing the position frequently, by avoiding areas of pressure under splints or casts, by keeping the skin dry and clean, and by using a rubber mattress and clean, smooth, bed sheets. If the condition has already developed, pressure on this area must be relieved immediately. If superficial and not grossly infected, the area involved may be kept dry and clean and permitted to separate spontaneously. If deep and grossly infected, it is important to remove all slough by sharp dissection, the use of pyruvic acid,<sup>17</sup> 3 per cent urea peroxide ointment, zinc and calcium peroxide ointment,<sup>10</sup> or Dakin's solution. As soon as the slough disappears from the wound, daily applications of zinc and calcium peroxide ointment dressings effectively control the infection, and permit growth of healthy granulation tissue and subsequent skin grafting of the area if necessary (Fig 454). Chemotherapy with sulfonamides or penicillin may be used to control any invasive characteristic of the infection, but its value is limited and definitely secondary to correction of the responsible mechanical factors and their effects.

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## CLINICS ON OTHER SUBJECTS

### CORRECTION OF CICATRICIAL CONTRACTURES OF AXILLA, ELBOW JOINT AND KNEE

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DERMATOGENOUS or desmogenous contractures are caused by the destruction of the surface and deeper parts of the surface tissue, as, for instance, after extensive burns. They usually occur at the flexor surface of the extremities or at the junction of limb and trunk. Aside from the joints of the hand, the joints most often involved are axilla, elbow joint and knee. In the majority of cases, much can be done to avoid contractures by early skin grafting. There are, however, instances in which a skin graft operation is contraindicated because of the patients' impaired general condition, or large grafts are not available, or fail to "take." In those instances, proper immobilization of the affected limb may counteract the contracting forces during the waiting period. In case knee and elbow joints are involved, the extremity is immobilized on a molded plaster cast splint. Plantar flexion of the foot can be avoided by placing a wooden box between the foot and the bed so that the patient can brace the injured foot against the box, or a molded plaster cast splint is applied including the foot. Contractures of the axilla are difficult to counteract. The arm should be placed in right angular abduction and kept in this position with the aid of pillows. However, these measures should not be painful or cause undue discomfort.

If, in spite of all these measures, a contracture starts developing, nothing forcibly should be done to overcome it, unless the patient is ready for operation. Blair and Brown and their associates, Koch and others, have pointed out that a raw surface in the flexor region of joints often decreases in size not so much by the overgrowth of epithelium from the periphery of the wound as by drawing in of the adjacent tissues. If the process is permitted to take place without interference, healing goes on rapidly. If, on the contrary, the contracting joint is irritated by repeated forceful dressings, there will be a greater production of fibrous tissue followed by more extensive shrink-

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age Or, if the extremity is forcefully stretched under anesthesia and fixed in this position, wide fissures are opened in the granulating wound with the possibility of infection delay of healing and production of larger and denser scar tissue What really is needed in such a case is the early covering of the raw surface with a skin graft regardless of the degree of contracture After healing has taken place proper physical therapy should be instituted to lessen the contracture Further operative procedures however, may become necessary to overcome a remaining deformity

To correct a contracture several procedures or a combination of various procedures are available If the contracture is caused by web formation and the surrounding skin is pliable one or several Z operations are the method of choice In contractures due to broad dense scars the latter are incised or excised the contracture is reduced and the resulting defect is covered either with a skin graft or with local or distant flaps We are indebted to J B Brown for having perfected the technic of skin grafting to such a degree that it has become the method of choice in the majority of contractures where a flap formerly was considered indicated

#### AXILLA

Three methods of repair are available Each one has its special indication

**Z Operation**—The indication for this operation (Fig 455) arises when the contracture is due to binding webs and the surrounding skin is pliable Sometimes the web is so long that it necessitates several Zs (Fig 456) Sometimes the arm is bound to the chest by several webs which all have to be broken up

**The Use of a Graft**—This method is indicated whenever the scar is broad but vessels or nerves do not need to be exposed or if exposed can be covered by surrounding fat tissue The contracture is released with a transverse relaxation incision through the entire thickness of the scar Excision of the scar is rarely necessary The incision should not be made through the center of the scar but near the chest wall *This will shift the defect rather toward the chest below the axilla* The arm is now forcibly abducted and all cicatricial bands as they present themselves in the wound are incised or excised The surgeon soon reaches the vena axillaris Abduction should now be carried out cautiously Stretching of the vein can be facilitated by ligating and separating some of its branches coming from the chest wall The other contents of the axilla should not be exposed The pectoralis major as well as the latissimus dorsi may become an obstacle resisting reduction of the contracture In the majority of cases the muscles can be stretched Stretching can be facilitated by separation of some of the fibrosed fibers running within the muscle substance They can easily

be palpated, while the arm is held in abduction. Incision of the free borders or severance of the insertion of the muscles is rarely necessary.

The defect, which is diamond-shaped, is now prepared for skin grafting. Hollow spaces, as for instance beneath the pectoral muscle, are obliterated by tacking the free border of the muscle to the axillary

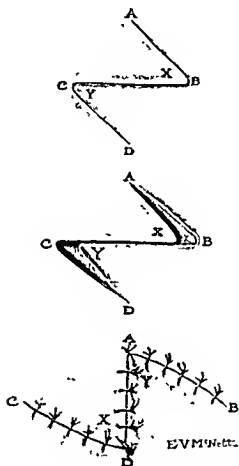


Fig 455—Z operation for contracted scars due to binding webs. The central line of the Z is laid upon the most prominent portion of the web (C-B) and the arms of the Z are marked out on opposite sides of the center line in 45 degree angles. Points A and D should lie in vertical projection of the center of C and B. The two triangular flaps are outlined and exchanged. The object is to interrupt and displace the binding web. (Redrawn from J S Davis, "Use of Relaxation Incision When Dealing with Scars," *Pennsylvania M J*, 41:565, 1938.)

fat tissue. Vessels and nerves, if exposed, must be covered with surrounding fat tissue. From the thick wound edges, a wedge-shaped piece of the dense fibrotic subcutaneous tissue should be excised. The now overhanging skin edges are either turned downward and sutured to the base of the wound, or, if they are pliable, they are turned out-

ward and folded over, so that skin comes to lie upon skin. The wound edges are held in this position with a few sutures (Fig 457). Blair recommended this procedure for the purpose of increasing the size of the graft bed to compensate for postoperative contraction.

The area is now ready to be grafted. The graft of choice is the thick split graft. Full thickness grafts have less chance of 'take' due to irregularity of the graft bed and difficulty with complete immo-

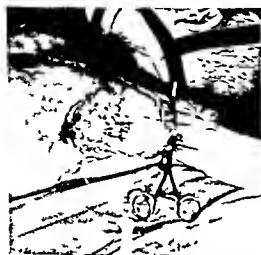


Fig 456—A Posterior view of patient with a binding web of anterior part of axilla. B Condition corrected by double Z operation which broke up the binding web and released the contracture. C Patient three months after repair.

bilization. Preferably the graft should be removed in one piece. It must be sutured carefully to the wound edges and anchored to the bottom of the wound. To facilitate this I found the following steps helpful. The graft is first sutured to the anterior wound edges; it is now lifted up and under direct vision the anchoring basting sutures are led through the graft and the depth of the wound. This not only facilitates accurate stitching but avoids injury of such important structures as the vena axillaris. Another row of similar sutures may be

necessary along the deep posterior boundary of the axilla. And, finally, the graft is sutured to the remaining wound edges.

The usual pressure dressing is applied after numerous stab holes have been made in the graft. The arm is held in abduction by fasten-



A



B

Fig 437—*A*, Contracture of left axilla from old burn scar. Contracting scar was incised, the contracture reduced. The lateral wound edge was everted and sutured to the skin of the arm so that skin came to lie on skin (Kelly clamp behind the everted skin). This increased the raw surface to counteract recontracture (Blair). The defect was covered with two skin grafts. *B*, Result after four months.



A



B

Fig 438—*A*, Extensive contracture of left axilla from burn. *B*, The scar was incised near the chest, the contracture reduced and the defect covered with two skin grafts. Result six months after the operation.

ing the hand to the head end of the bed and supporting the arm with pillows.

The dressing is changed after seven days, active exercises should be

tarted after ten days After three weeks passive motion exercises should be added One of the simplest is exercise on the swing If in spite of active and passive exercises the contracture should recur to some degree, another skin graft operation should be performed

*Variation*—There are cases of contracture in which a strip of normal or at least pliable, skin is left in the depth of the axilla In these cases the relaxation incision is not carried through the axilla but along the median border of the pliable skin portion, i.e., along the chest wall (Burton) (Fig 459 right axilla) If the arm is forcibly abducted



Fig 459—A Contracture of both axillae and right elbow joint from normal skin in right axilla An incision was made along the median border of normal skin at the right side of chest (see dotted line) This part of the skin was undermined and the contracture reduced The defect was covered by a large skin graft A skin graft repair to overcome the contracture of the elbow was unsuccessful hence, a tube flap was made from the immediate neighborhood and transplanted in stages The contracture of right elbow joint was relieved by a Z plastic B Result four years after the operation

the skin lateral to the incision partially by dissection partially by pushing it laterally moves upward and is held in the new position by sutures Or, it may be turned outward as described above The defect at the chest wall is skin grafted as described above

*The Use of a Flap*—In those cases of extensive contracture the binding scar consists of heavy dense fibrous tissue and partial excision of the scar and exposure of vessels and nerves come the contracture without available fat tissue to cover the defect requires transplantation of a flap for covering the defect

cated (Fig 459, left ankle) Another indication for the use of a flap is previous failures to correct the contracture by the free graft method

A



B



Fig 460—*A* Carcinoma of breast Incision outlined Two opposite points at the extreme parts of the curves outlined by two dots which facilitate correct approximation of the wound edges later on (see text) *B*, After closure of the wound Patient was able to raise the arm without any limitation of motion one week after the operation

The flap is preferably taken from the neighborhood (chest or back), and as a rule needs to be made so long that delayed transfer becomes



necessary. Occasionally a flap can be rotated from the immediate neighborhood into the defect in one stage and the secondary defect, consisting of the original flap bed, be skin grafted. Or two flaps may be needed. Davis suggests raising one from front and the other from back, the free ends being sutured together.

**Prevention of Contracture after Radical Amputation of the Breast.**—A popular incision in radical operations for cancer of the breast is the elliptiform incision around the diseased breast and its longitudinal extension upward along the lateral border of the major pectoral muscle. It is this latter part of the incision which in a certain percentage of cases, causes limitation of motion of the arm in the shoulder joint later on. After removal of the pectoral muscles, the incision or rather the resulting scar comes to lie across the axilla. If this scar contracts it becomes a bridle scar or a binding web.

To counteract the possibility of a contracture by a binding web it seems logical to perform the Z operation with formation and interposition of two triangular flaps at the time of the first operation. This can be done by making additions to the original longitudinal incision. The object of such a procedure would be, first, to interrupt the longitudinal direction of the original incision and to change it into a transverse or oblique course, and secondly, to increase its length. The condition could now be compared to that of an accordion.

The same result can be achieved with a much simpler procedure by changing the straight course of the longitudinal incision into a spiral form (Fig. 460). The course of the incision is marked out preoperatively with one of the aniline dyes. One third of the spiral should lie anterior to the border of pectoralis major, two thirds posterior to it in the axilla.

There are two precautions to observe: first, not to make the spiral cut too steep and too high, second, to mark two opposite points at the extreme parts of the curves with a drop of methylene blue injected percutaneously into the skin. This will facilitate correct adjustment of the wound edges later on.

#### ELBOW JOINT

The underlying principles in repairing flexor contractures of the elbow joint are the same as those for the axilla. If a Z plastic is possible, partial or even complete relief can be achieved. In some instances, a combination of Z plastic and skin grafting will lead to success. In extensive contractures, particularly those of long standing, the contracted biceps and involvement of the joint structures may offer a major obstacle in reducing the contracture. When opening the contracture, great care should be taken not to injure main vessels or nerves and not to expose tendons. If it is found impossible to relieve the contracture completely, without exposing or endangering those struc-



B

Fig 461—A, Eight-year-old boy with contracted scar of right elbow joint and axilla from burns. Burned area included entire right half of chest and abdomen. Contracting scar of right elbow joint was thick and heavy. A tube flap was made from left thoraco-epigastric region (Webster). The contracting scar of elbow joint was incised, the contracture reduced after separation of the biceps tendon and the defect covered with the tube flap which had been transferred via the left wrist. Contracture of right axilla repaired by Z operation. B, Condition three years after repair. Note length of flap in elbow joint (X-Y).

tures, one should be satisfied with a temporary partial success, i.e. skin graft the defect, encase the extremity in a plaster cast and repeat the procedure after healing has taken place. In those extensive cases in which exposure of the contents of the cubital region and tendon lengthening must be anticipated, the use of a flap becomes primarily the method of choice. The length of the flap makes a delayed transfer advisable. The flap is prepared before the actual repair of the contracture is undertaken. A direct transfer of the flap can be planned if it is possible to raise the flap from the lateral chest region of the same side. The direction of the flap is transverse, the pedicle located anteriorly opposite the contracted joint. The flap should be the open type and prepared in stages, or, a flap is taken from more distant regions and then transported by way of the wrist of the other arm. Such a flap should be tubed (fig. 461). If lengthening of the biceps tendon becomes necessary, the Z method is effective. However, in a few instances, the contracture of the biceps is so extensive that even the Z plastic is insufficient to permit complete reduction. If such is the case one should not hesitate to sever the biceps tendon and either transfer its insertion to a position higher up (Schmieder) or permit the tendon to retract without suturing.

Where almost the entire joint region is enveloped in a large thick contracted scar, a relaxation procedure such as described under contractures of the knee joint should be given a trial.

#### KNEE JOINT

The principles in correcting a contracture of the knee joint are similar to those described in previous paragraphs. Flaps are rarely needed. If needed, they are taken from the opposite thigh or transferred from the opposite thoraco-epigastric region by way of the wrist of the same side. The relaxation incision is led transversely through the most binding area. Care should be taken not to expose the popliteal contents, particularly not the tendons. If the contracture cannot be overcome in one stage the defect is skin grafted, the extremity encased in a plaster cast and one or more similar procedures performed subsequently. The first plaster cast should not be changed for at least two weeks unless there is evidence of infection.

In this way, most of the contractures, even extensive ones, can be repaired. There are, however, instances when, although the contractures can be overcome in longitudinal direction, the result is spoiled by a posterior subluxation of the tibia due to shortness of the posterior ligaments. O'Donaghue recommends a horizontal and vertical traction to the leg. In extensive cases, however, traction is not successful. We have been able to reduce the subluxation, as evidenced clinically and roentgenologically, but as soon as traction was removed the subluxation recurred within a few days. Hence, we recommend reducing the

subluxation under traction followed by application of a plaster cast with incorporation of the pins. The cast should be applied while the leg is suspended in traction. The pins and the anterior half of the cast are removed after two weeks while the posterior half is kept to be applied during the night. Active exercises are instituted. We found

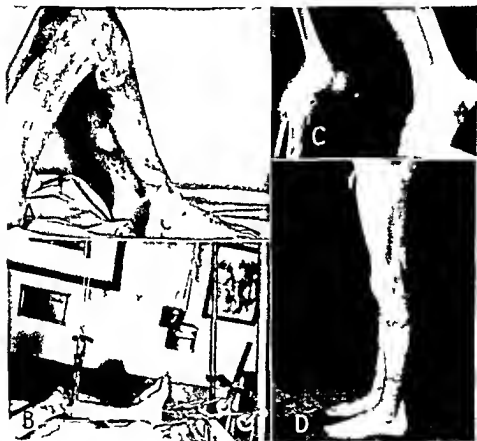


Fig 462—A Extensive turn of both legs, contracture of both knee joints. B The raw surface covered with skin grafts the contracture partially reduced. Posterior subluxation of the tibia due to contracture of posterior ligaments and capsules to be overcome by longitudinal and vertical traction. C X-ray picture of same patient showing on the left the posterior subluxation of the tibia on the right the reduction of the subluxation by traction. Later a plaster cast was applied in this position with incorporation of the wires. D One year after operation.

resistance exercises to be particularly valuable such as active motion of the knee after placing one sandbag beneath the leg and another upon the thigh. Walking is also permitted (Fig 462).

Old contracted extensive heavy thick burn scars which may involve the entire knee joint and lower extremity are troublesome and difficult to correct. It would be inadvisable to remove the whole scar as it would be impossible to obtain sufficient skin with which to cover

the defect. To relieve these large thick scars, *Davis' relaxation procedure* is a good one (Fig 463). The contracted region is put on a stretch and the most binding area or areas are located and marked out. The scar is divided completely through its full depth until normal tissue is reached. Sometimes radiating incisions from the margins are necessary to complete relaxation. If, after the incisions are made the scar is found to be very thick, excision of a wedge shaped slice of the deeper layer is advisable so that the thinned surface edges may be

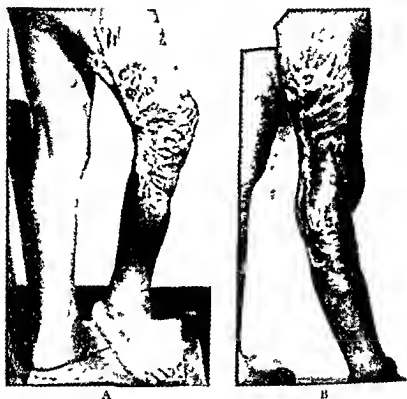


Fig 463—A Extensive thick contracted scar of right knee joint from burn. B, Three years after the operation. The most binding areas of the scar were severed by transverse incisions the contracture reduced and the resulting defects covered with skin grafts.

drawn downward and attached to the normal base by a few sutures. The defects are now covered with split skin grafts a pressure dressing is applied and the extremity is encased in a plaster cast. In rare instances where the contracted flexor muscles present the main obstacle tenotomy of the latter should be performed. The tenotomy should be made oblique. Before tenotomizing the biceps the peroneal nerve running median and close to the tendon should be exposed and held away. The deep portion of the biceps insertion should be left

behind to avoid separation of the important ligamentum collaterale fibulare. The tendons of the musculus semitendinosus, semimembranosus and gracilis are tenotomized on the median side. If there is a tendency to posterior subluxation of the tibia, traction should be applied in a way similar to that described above.

#### SUMMARY

Various methods to correct contractures of axilla, elbow joint and knee are described. The Z operation is the method of choice to break up webbing scars. Contractures due to broad, dense scars are repaired by incising or excising the scar, reduction of the contracture and covering the resulting defect with a skin graft, or less often, with a flap. Contractures from old, contracted, extensive thick burn scars are corrected by relaxation incisions and skin grafting.

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# CONGENITAL ATRESIA OF THE GALLBLADDER AND BILE PASSAGEWAYS

## Report of Two Cases

MOSES BEHREND, M.D., F.A.C.S.\*

As a result of the studies concerning erythroblastosis and the Rh factor in the blood, sufficient time should be allotted for the determination of the proper diagnosis in cases of jaundice in newborn infants. Nevertheless, in the two cases of jaundice resulting from congenital atresia of the gallbladder and bile passageways that I wish to report, the infants were held under observation too long before a remedial surgical operation was contemplated, and death occurred. Jaundice at any age has a devastating effect upon the human economy. It causes degeneration of the vital organs. Persistent jaundice surely ends in death, on account of the biliary cirrhosis that follows in addition to the changes mentioned. It may generally be stated that any patient with jaundice lasting more than four weeks should have the benefit of an operation. There are very few exceptions to this rule.

According to Mottsay and May, about 200 cases of atresia of the gallbladder and bile passageways have been reported. In a report at the Staff Meeting of the Mayo Clinic, Amberg and Zuschlag quoted Stolkind, who reviewed 245 cases and found that thirty-one additional cases were unpublished. Ladd and Gross have contributed much to the surgical technic of these congenital anomalies. Ladd states that a cure by means of surgery is possible in at least 37 per cent.

The cause of these congenital deformities is unknown. The first case coming under our observation was operated upon in 1943. There was absolute obliteration of the hepatic duct. The gallbladder, cystic and common ducts were patent. In the second case, the cystic duct, without lumen, inserted itself into the liver at its fissure. The hepatic and common ducts were absolutely closed.

### CASE I

D. D., a white female infant aged ten months, was admitted to Mt. Sinai Hospital October 16, 1943, on the service of Dr. Samuel Rubin.

History—Birth was normal, the baby weighing 7 pounds and 2 ounces. Immediately after delivery the parents noted the baby's dark olive complexion. Her color deepened steadily. During the last two months the color of the urine has become orange and darker than usual. Stools one to three daily, have always been white or yellow in color. The eyes are puffy in the morning, but the phenom-

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enon recedes during the day. The abdomen is becoming progressively distended, and the abdominal veins are marked. The child has two sisters, both in good health.

**Physical Examination**—A markedly jaundiced baby with distended abdomen who cries most of the time is seen. The sclera are yellow. Pupils are equal and regular and react alike. The mucous membrane of the mouth is yellow tinged. Examination of the abdomen reveals the lower border of the liver could not be palpated. The spleen is apparently normal in outline. Ascites is probably present.

**Laboratory Examinations**—The urine is dark amber, alkaline, with a specific gravity of 1.020. A marked trace of protein is present. Blood studies: hemoglobin 5.13 gm (36 per cent), red blood count 1,900,000, white blood count 10,200, polymorphonuclears—segmented 56, nonsegmented 5, lymphocytes 35, monocytes (transitional) 4, marked achromia, some anisocytosis and poikilocytosis, slight polychromatophubia. The blood prothrombin concentration is 23 per cent, icterus index 192, blood bilirubin 5.4 mg., cholesterol 165 mg and cholesterol ester 72 mg per 100 cc of blood serum. The stool shows bile with a trace of urobilinogen.

**Clinical Diagnosis**—Obstructive jaundice due to congenital absence of the bile ducts.

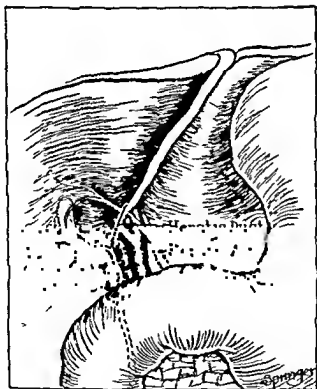


Fig 464 (Case I)—Note the complete obliteration of the hepatic duct. The gallbladder, cystic and common ducts had a slight lumen. A drainage tube placed over the cut hepatic duct revealed no bile after operation.

**Operation.**—After a series of transfusions operation was performed on October 29, 1943. Under ether anesthesia, with the patient in the dorsal position, a right rectus incision was made. Every tiny bleeding point in the superficial fat and skin was ligated. Upon opening the peritoneum, a vestigial gallbladder could be seen. This was grasped



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**Comment**—Death occurred in an infant with congenital atresia of the hepatic bile ducts, advanced liver cirrhosis resulting from obstructive jaundice. In this case a drainage tube was placed over the cut into the hepatic duct with the hope that bile would exude following the operation. The dressings after operation were devoid of bile.

## CASE II

H. H., a white female infant aged five months was admitted to Mt. Sinai Hospital on December 11, 1944, on the service of Dr. Paul Morris and died February 9, 1945.

**History**—The pregnancy was uneventful and full term. The baby was doing well up to the fifth day. Then she lost eight ounces in weight and the lack of desire to nurse was noted. While the mother was feeding the baby the baby suddenly began to bleed from the nose and became very cyanotic. The mother had noticed since birth that the baby's skin was darker than normal but attached no particular significance to it. Since birth the stools have been very light in color and for the past six weeks the baby has had ten bowel movements a day of normal consistency. The urine has always been dark and ammoniacal. There has always been a tendency of bleeding from the gums even without the slightest trauma.

**Physical Examination**—Examination reveals a well nourished but jaundiced female child who appears very irritable. A large hemangioma has developed on the top of the head. There is a similar but smaller hemangioma on the upper lip. The sclerae are somewhat jaundiced. The neck is normal. The heart is not enlarged. Sounds are rapid, regular and rhythmic. The abdomen is somewhat distended but unusually tense. The spleen is greatly enlarged. The liver is somewhat enlarged. A large umbilical hernia is present. Extremities are normal. The skin all over the body has a greenish yellow tinge.

**Laboratory Examinations**—Not enough urine was obtained for a thorough examination. Bile was however present. Blood studies: hemoglobin 9.8 gm (68 per cent) red blood count 3,600,000 white blood count 22,300 polymorphonuclears—segmented 21 nonsegmented 9 lymphocytes 69 monocytes (transitional) 1 platelet count 240,000. Hemolysis begins at 0.44 and is complete at 0.30. Icterus index—84 units to 124 units van den Bergh 3.2 mg per 100 cc of blood prothrombin time 95 per cent Wassermann and Kline tests negative. Intravenous urography reveals good function on both sides with the kidney and ureters normal. No bilirubin is found in the stool. X-ray reveals no abnormalities of the colon.

**Clinical Diagnosis**—Congenital obstruction of the common duct.

**Operation**—After a series of transfusions operation was performed on December 18, 1944. With the patient in the dorsirecumbent position under ether anesthesia, a right pararectus incision was made from the xiphoid cartilage down to below the umbilicus. The abdomen contained quite a large amount of straw colored fluid. The liver was markedly enlarged and very hard, the surface slightly nodular and yellowish brown. The left lobe extended over to the splenic area. On the undersurface of the liver there was a small cordlike structure which appears to be an atrophic gallbladder. On dissection of the gastroduodenal hepatic ligament, a very large portal vein was found. Extending across the upper end of the portal vein was a large hepatic

artery. Coursing along the portal vein and beneath the hepatic artery was a thin atrophic structure which apparently represented an atretic common bile duct and hepatic duct (Fig. 465). The gallbladder was opened and the fundus was removed. A small lumen was found and probed. A small amount of dark-green bile was obtained. A small ureteral catheter No. 4 was placed into the lumen in the hope that bile would present itself. The left retroperitoneal space was palpated and no mass was felt. The peritoneum and fascia were closed with

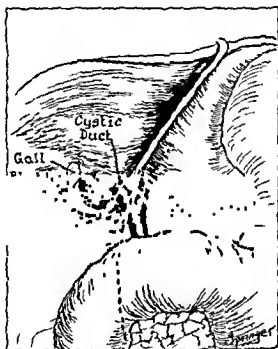


Fig. 465 (Case II) —Complete atresia of the hepatic and common ducts. The cystic duct was independently inserted into the liver and a No. 4 ureteral catheter was placed in its lumen. There was no drainage of bile following the operation.

continuous No. 0 chromic sutures. The skin was closed with interrupted black silk sutures.

**Comment**—This patient suffered from absolute congenital occlusion of the hepatic and common ducts. The cystic duct was independently inserted into the liver with no bile drainage. The gallbladder had a slight lumen containing a few drops of liquid bile. A No. 4 ureteral catheter was placed in the bisected gallbladder and the cystic duct. There was absolutely no drainage of bile after operation. The patient died of biliary cirrhosis with degenerative changes in the other organs fifty-three days after operation. In the interim she gained and lost weight due to ascites which had to be relieved by paracentesis.

## PATHOLOGICAL REPORT

## Gross Pathologic Diagnoses

## Histological Diagnoses

*General* Marked diffuse icterus, mod-

*Circs*

*Blood Vessels* Normal.

*Heart* Cloudy swelling

*Lungs* Slight congestion

*Spleen* Give accessory spleens, marked congestion

*Gastrointestinal Tract* Marked gastric distention peripyloric and duodenal adhesions, focal small intestine adhesions; marked distention of small intestine moderate distention of large intestine

*Liver* Marked biliary cirrhosis.

*Gallbladder* Hypoplastic gallbladder (2), congenital absence of common bile duct and cystic ducts; marked adhesions in region of gall bladder (2) and anatomic biliary duct system

*Pancreas* Congestion

*Adrenals* Normal

*Kidneys* Moderate congestion

*Bladder* Normal

*Genitourinary Tract* Normal

*Lymph Nodes* Lymphadenitis

*Bone Marrow* Congestion

*Thymus* Xanthomatoid cellular foci

*Heart* Cloudy swelling

*Lungs* Focal microscopic alveolar hemorrhage, chronic metaplastic bronchus, slight septal fibrosis, focal microscopic atelectasis

*Spleen* Congestion moderate fibrosis

*Liver* Marked active biliary cirrhosis with extensive biliary stasis

*Pancreas* Cloudy swelling

*Adrenals* Cloudy swelling

*Kidneys* Cloudy swelling, diffuse non specific early glomerular hyalinization

*Bladder* Normal

*Lymph Nodes* Acute lymphadenitis

## CONCLUSIONS

A report of two cases of atresia of the gallbladder and bile passages is presented. A plea is made for the earlier reference of these cases to the surgeon for operation. One patient died the day of operation, the second fifty-three days after operation.

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### SYMPOSIUM ON RECENT ADVANCES IN GYNECOLOGY AND OBSTETRICS

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#### FOREWORD

THE material presented in this volume is an earnest effort to bring the recent advances in gynecological and obstetrical practice up to date. Although postgraduate refresher courses have been established, so much has been added to the literature in connection with the advances made that physicians returning from the Armed Forces would find it almost impossible to review and digest all the material. We have endeavored to select the outstanding newer methods and techniques for presentation in this single volume. The authors of these varied subjects are physicians who have gained an enviable reputation in the profession, among them members of the teaching staffs of medical schools who are recognized as authorities in their special fields.

Although all of the contributors have been overburdened during the past four years in the performance of their duties, their home front efforts are highly commendable, as they have added valuable scientific work and results of clinical investigation to both gynecological and obstetrical practice. Many of these articles describe new improved tests and discoveries, others are reports of improvements in older and out-moded techniques.

Much of the subject matter has been contributed by members of the Department of Obstetrics and Gynecology of the Jefferson Medical College and the Woman's Department of the Pennsylvania Hospital, some by specialists in private practice. It is hoped that this collection of important articles may stimulate other members of the profession to contribute their clinical results. We who have remained at home to carry on the practice of our specialty are making an effort to give to our returning veterans of the profession a brief and concise survey of our special fields and I am deeply grateful for the privilege of contributing my small share.

NORRIS W. VAUX, M.D.

## DIAGNOSIS AND MANAGEMENT OF UTERINE CARCINOMA AND SARCOMA

LEWIS C SCHEFFEY, ScD, MD, FACS \*

PELVIC malignancy represents the gravest of gynecologic disorders and the most frequent site is in the uterus. Carcinoma is commonest and the cervix is most often affected, the portio chiefly and the mucosa of the canal infrequently. Next in order is fundal involvement. Sarcoma is relatively infrequent. In this presentation, diagnosis and management will be stressed almost entirely.

### CARCINOMA OF THE CERVIX

**Diagnosis**—Carcinoma of the cervix respects no so called "cancer age." Although the majority of cases occur at the time of the menopause and thereafter, it is often encountered during the reproductive period, in fact 27 per cent of the patients seen in the Jefferson Clinic have been under forty years of age. This means that one should not dismiss the possibility of relatively young women becoming the victims of cervical cancer.

While chronic irritation and cervical trauma are probably not the sole factors in the development of carcinoma, it is logical to assume that chronic endocervicitis, papillary eversion and erosion, with hypertrophy of the cervix, may be due either from venereal infection or to this may be added rather uncommonly as a cervical lesion.

For these reasons, any cervix that presents abnormalities should be adequately treated, and routine biopsy from one or more areas presenting the lesions mentioned should be employed promptly either to establish or exclude carcinoma. It may even be necessary in some instances to split the cervix when the portio seems intact, in order to secure tissue from the cervical canal where malignancy may exist as adenocarcinoma—an infrequent but sometimes overlooked site. A clear cut diagnosis can usually be made in this manner, but TeLinde and Galvin have emphasized the importance of detecting the minimal histologic epithelial changes in the cervix that justify a diagnosis of malignancy, a problem which has provoked considerable controversy among gynecologic pathologists. A difference of opinion in this respect has arisen because squamous cell metaplasia and epidermization may closely resemble actual carcinomatous change. However, TeLinde has presented evidence of invasive cervical carcinoma in removed

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teri, in which the preliminary biopsies were regarded as malignant, which he thinks adequately justifies his stand with regard to the vital significance of these preinvasive intraepithelial changes. We are attempting to confirm these observations in the Jefferson Clinic. In any event, this work would seem to indicate the desirability of endothermic resection of the cervix or a surgical amputation of the Sturmdorf type designed to obtain generous amounts of cervical tissue for study, in preference to repeated single or multiple biopsies of localized lesions. While abnormalities of menstruation or intermenstrual bleeding may be functional and associated with endocrinopathies, this should not be assumed until an organic lesion, benign or malignant, has been ruled out by thorough examination and by appropriate diagnostic procedures. This same principle applies to an offending leukorrheal discharge, which may be the result of venereal infection of varying degree, parasitic infestation, or of low grade infection associated with the lacerated and everted cervix. When uterine malignancy exists, leukorrhea is much more representative of necrotic tissue change.

Abnormal uterine bleeding then, either alone or associated with leukorrhea, may be the first evidence of cervical carcinoma. Unfortunately, such symptoms are too often disregarded, not only by the patient but by the physician to whom the patient appeals for an opinion. The reasons for this negligence are so time-worn that extended discussion is painfully repetitious. Too often the patient herself simply resorts to douches or proprietary remedies, or she may be content with her neighbor's statement that the condition is due to "change of life." On the other hand, medical consultation may be utterly unproductive of positive results, either because of lack of knowledge and training, delay in examination or simply because of inertia. The indiscriminate use of endocrine therapy, so popular today in the attempted alleviation of any female complaint, may only tend to further obscure, confuse and postpone an accurate diagnosis with consequent failure to institute proper treatment promptly. The hypodermic needle and oral medication have too often replaced the discerning eye and the sensitive finger.

Unfortunately, it is true that in some instances there may be no objective symptoms of cervical malignancy. That is why periodic pelvic examinations offer hope and opportunity for early diagnosis. The campaigns conducted by the American Cancer Society, and by other appropriate lay and medical groups, are of exceptional value in stressing to the public the importance of regular physical surveys, for only in this manner can symptomless or suggestive lesions be detected. The cooperation of the medical profession is vital to the success of such programs, and they should be participated in by individual physicians as well as by organized medical bodies.

With respect to the diagnosis of uterine malignancy in general, one of the most concrete advances has been in the development of the



*vaginal smear technic.* As originally described by Papanicolaou, the test depends upon the ability of the examiner to recognize the atypical cells found in carcinoma of the cervix and fundus as contrasted with the normal cells of the vaginal secretion which are of three distinct groups—cornified, basal and endometrial. Naturally, a long period of training is required before an examiner may be regarded as qualified to detect the abnormal cells that are characteristic of malignancy. Special training methods are necessary and essential cytological criteria have been established. The reader is referred for detailed information to the original writings of Papanicolaou and to the more recent presentations of Meigs.

Prolonged experimental work has been and is being done in the Jefferson Cancer and Cancer Prevention Clinics in this respect, under the immediate direction of A. E. Rakoff with the cooperation of J. Hoffman, a complete report of which is planned for future publication. All results to date have been promising and in conformity with the investigations mentioned. The approach in our plan of study has been somewhat different, characteristic results may be summarized briefly as follows:

Vaginal smears have been taken for examination on 500 consecutive patients admitted to the Gynecological Ward of the Jefferson Hospital. These were benign lesions. The results of the smears which were taken by number only were compared with the final diagnosis particularly the histologic diagnosis as determined by Doctor Hoffman.

In the first 155 cases studied, which have thus far been completed there were 132 nonmalignant lesions and twenty three malignant lesions.

Of the 132 nonmalignant lesions, 129 were indicated as being nonmalignant. Of the 23 malignant lesions, 18 were properly diagnosed as malignancy from the vaginal smear. These include fifteen cases of carcinoma of the cervix, two cases of fundal carcinoma and one myosarcoma. One fundal carcinoma and four cervical carcinomas were missed by vaginal smear.

Of the twenty-three malignant lesions, eighteen were properly diagnosed as malignancy from the vaginal smear. These include fifteen cases of carcinoma of the cervix, two cases of fundal carcinoma and one myosarcoma. One fundal carcinoma and four cervical carcinomas were missed by vaginal smear.

Considerable research of a confirmatory nature will have to be accomplished before the diagnosis of uterine cancer can be relied upon by the vaginal smear method, without further corroboration by biopsy and curettage. Its chief value at present lies in the fact that the detection of these atypical cells in the routine vaginal smears of patients without objective evidence of uterine malignancy, calls for immediate biopsy and/or curettage. This promises earlier recognition of a microscopic lesion than would otherwise be the case. Certainly the method is of much more value than either the Schiller test or the colposcope, for both of these methods are inconclusive and their employment merely calls attention to abnormal cervical areas that had better be resected or at least biopsied.

**Management**—The treatment of carcinoma of the cervix, whether by irradiation or surgery, is chiefly controversial in one respect—the management of the supposedly early case. When reasonable doubt exists that the cancerous growth is no longer limited to the confines of the cervix, and irrespective of possible lymphatic metastasis, there should be no hesitancy in selecting irradiation therapy in preference to a primary surgical procedure.

There are today relatively few gynecologists and general surgeons in this country who either by training, ability or inclination, perform the classical Wertheim operation. Simple performance of panhysterectomy, with removal of the adnexa, is not a Wertheim procedure. In this country, the late Frank W. Lynch of San Francisco was the outstanding exponent of this truly radical procedure, in which it is necessary to perform block dissection and removal in entirety of the uterus, adnexae, parametria, uterosacral ligaments, iliac and sacral lymph nodes, and the upper half of the vagina. In addition, the obturator and hypogastric nodes should likewise be resected, the ureters freed from their surrounding tissues, and the rectum and bladder freely mobilized. As a preliminary step to this formidable surgery, Lynch generally applied radium to the cervix and cervical canal—usually employing a dosage of 3000 to 3500 mg.-hr. In his series of fifty-eight carefully selected patients, reported in 1940, the five-year survival rate was 63.6 per cent, with four deaths, a primary mortality of 5.4 per cent (relative), occurring among the twenty-one patients who had not received preliminary irradiation. There were no postoperative deaths among the thirty-seven patients who had received radium before operation.

Lynch was inclined to operate on early cases of cervical carcinoma because he had already proved the presence of apparently viable cancer cells in cervixes removed after irradiation, but he stated very definitely that "the surgical treatment is logical only if attended by an operative mortality rate which is smaller than the percentage of radio-resistant carcinomas—those which do not react normally to the action of radium rays and which consequently cannot be cured by irradiation." Thus it is apparent that the scalpel has definite limitations and at least three criteria must be complied with when surgical treatment is chosen for cervical carcinoma: first, an early lesion (Groups I and II, Schmitz and League of Nations), second, a relatively young, non-obese individual, presenting no definite operative contraindication, third, a truly radical operation, performed by an operator of judgment and experience.

Abroad, Victor Bonney of London has always operated for cervical carcinoma to the exclusion of irradiation, except in far advanced cases. His criteria for surgery have been much less confining than in this country. This is evidenced by the fact that he places his operability at 63 per cent. In 1941 he reported upon a series of 500 patients oper-

ated upon by his beautifully-developed Wertheim technic. His five-year survival rate was 40 per cent, his primary mortality rate was 14 per cent (relative). There was no lymph node involvement in 300 of these patients, there was a five-year survival rate of 53 per cent, and a primary mortality rate of 10 per cent in this group. On the other hand, the remaining 200 patients showed lymph node involvement and in this group the five-year survival rate was 22 per cent, and the primary mortality 20 per cent. Bonney estimates that lymph node involvement is generally present in perhaps 40 per cent of all cases of cervical carcinoma, which corresponds closely to Morton's figure of 44 per cent, reported from the University of California Clinic in 1935.

From the work of these two master gynecologists, it is evident that the question of five-year survival after the radical Wertheim operation is closely related to the state of lymph node involvement—the more extensive the latter, the less the chances of extended survival by any treatment. With this thought in mind, I would call attention to the work of the late Fred J. Taussig, of St. Louis, a proponent of iliac lymphadenectomy in selected cases. He felt that the Wertheim operation, with its extensive lymph node removal, could only be countenanced in Group I carcinomas. In Group II lesions, however, he favored preliminary x-ray therapy extended over four or five weeks, followed by bilateral salpingo-oophorectomy and iliac lymphadenectomy. This included the removal of the hypogastric, obturator, ureteral and external iliac nodes. Two weeks later radium was applied locally to the cervical lesion.

In reporting in 1943 upon a series of 175 Group II patients treated in this manner, Taussig found lymph node involvement in 26.8 per cent. The five-year survival rate was over twice as great in those patients having no lymph node metastasis—an expected finding. The operative mortality in this group of 175 patients was 1.7 per cent, the five-year survival rate among 70 eligible cases of this series was 38.6 per cent. When compared with 118 Group II patients treated only with irradiation, the five-year survival rate was 22.9 per cent—or about 15 per cent less satisfactory than with the additional lymphadenectomy.

More recently, D. G. Morton, of the University of California Clinic, has presented an interesting study along the lines of Taussig's endeavors, but differing in that he selected patients in whom the immediate local reaction to irradiation had been good, arguing that it was useless to resect the regional nodes unless there was a "reasonable chance of a successful outcome so far as the cervix proper was concerned." Consequently Group I, II and III patients were included in his series of sixty-five cases.

In one group of thirty-seven patients, all Group III cases, simple lymphadenectomy was the object, and that operation alone was performed in twenty-five instances, with incidental hysterectomy in eight

more plus the gland resection. Hopeless involvement in two made operation impossible, while in two others the operation was discontinued after palpation revealed no enlarged nodes.

In a second group of five patients (one Group I and four Group II), hysterectomy was the object, but lymphadenectomy only was carried out.

In a third group of twenty-three patients (five Group I, sixteen Group II, and two Group V) a Wertheim operation plus lymphadenectomy was performed.

In the entire series, involved nodes were found in fifteen (with freedom of involvement in forty-eight), or 23.8 per cent. However, in those patients in whom no preoperative x-ray was employed, the lymph nodes were involved almost four times as frequently. This has led Morton to conclude that "if it can be shown that modern x-radiation may actually destroy metastatic cancer in lymph nodes, then this nonoperative and possibly more comprehensive method may prove superior."

J. V. Meigs, of Boston, on the other hand, does not believe that it is possible to eliminate carcinoma in lymph nodes by irradiation, and since 1939 he has been performing Wertheim operations upon carefully selected patients, the majority of whom have had Group I and Group II lesions. In addition to accepting only relatively early growths for surgery, he prefers patients who are "thin, young, and in good health." Meigs is not certain as yet as to the advisability of preliminary irradiation, but he feels very definitely that Taussig's plan for Group II cases is inadequate and that removal of the uterus and parametria plus lymph node resection is superior to lymphadenectomy with irradiation, although he favors Taussig's method of lymph node dissection. In 1944 he reported upon a series of forty-seven elective patients, operated upon without mortality. In six nonelective cases, one patient died of general peritonitis, a mortality for the entire series of 1.9 per cent. Naturally, sufficient time has not yet passed for an evaluation of five year results. Meigs recognizes the limitations of surgery in the majority of cases of cervical carcinoma, but feels that his results justify the formidable technic that he employs in suitably early cases in preference to irradiation, for reasons stated in his very valuable contribution.

Vaginal operations for cervical carcinoma have never achieved the popularity in this country that they enjoyed abroad. L. Adler, formerly of Vienna, has presented the results of the Schauta operation, as well as his combined radium and surgical technic, and references to his reported results appear in the American literature. His most recent report, dealing with 1225 cases, and representing an accepted operability of 54 per cent, declared an operative mortality of 5.7 per cent. He also claimed a five-year survival rate of 39.4 per cent in a selected group of patients.

I have gone into considerable detail in discussing the role of surgery

in carcinoma of the cervix, because I want to show that there is really only a limited field for its application I say this because we have seen a rather constant percentage of Group I and II patients in the Jefferson Clinic over a twenty-four year period—a figure always approximating 12 per cent This is in accord with observations nearly everywhere It is a figure that does no credit to early diagnosis but it does point out a condition that has to be faced, viz., that the vast majority of cases of cervical carcinoma are not suitable for surgical procedures Furthermore, from the facts just presented it is obvious that when surgery is chosen, it must be carried out radically, meticulously and by an operator of the skill and experience of those mentioned Such operators are few and far between

In 1942, my associate George Hahn and I presented evidence of the results of inadequate and ill advised surgery in cervical carcinoma We reviewed carefully the records of eighteen patients subjected to surgery, in whom recurrence was relatively prompt A five-year survival period or better in but three of them was due entirely to irradiation therapy which controlled the recurrence of the lesion

It is our opinion, shared in by many, that irradiation is the treatment of choice in the overwhelming majority of cases, and that the chances furthermore, are best in Group I and II lesions Naturally, this is true only if the clinical response to irradiation is favorable, for prognosis based entirely on the histologic type of the lesion is of no practical value Surgery, under the ideal conditions that have been postulated, might cure a reasonable number of early cases because of the presence or persistence of radioresistant cellular elements, and because metastatically involved lymph nodes may not respond as well to irradiation as to surgery On the other hand, under average conditions of management, the patient with cervical carcinoma is likely to fare much better with irradiation therapy that has been carefully planned and executed

A League of Nations report in 1939 published internationally collected results with irradiation therapy that showed a five-year survival rate of 47.4 per cent in early cases (Group I and II), while the overall rate for all groups was 27.6 per cent

In 1941, Winterton and Windeyer presented a comparative analysis of their results with both surgery and irradiation that is particularly revealing Of 179 patients seen primarily, sixty-four were considered suitable for the Wertheim technic In this group, the five year survival rate was 36 per cent and the mortality rate was 17.2 per cent The survivals were twice as great when the lymph nodes were not involved Of the remaining patients, 104 were treated solely with irradiation and the five-year survival rate for Group I and II patients was 44 per cent, for all groups the survival rate was 25 per cent, while the overall mortality was 48 per cent

Shaw, of Manchester, speaking before the Clinical Congress of the

American College of Surgeons at Philadelphia in 1936 stated that both Dougal and he had abandoned the Wertheim operation in favor of radium therapy because of its applicability to all cases of cervical carcinoma and because of the comparatively low primary mortality. In addition to these advantages a five year survival rate of 41.4 per cent convinced him of the superiority of irradiation therapy over surgery in the vast majority of instances.

In the Jefferson Clinic, in existence since 1921 with a follow up of 98 per cent, no surgical procedures have been employed since 1923. The relative five year survival rate of those patients treated solely with irradiation according to groups is as follows:

Group I	75.0 per cent
Group II	43.3 per cent
Group III	22.1 per cent
Group IV	0.0 per cent
Group V	13.3 per cent

Hence the relative survival rate for early cases (Groups I and II) has been 47 per cent while the overall rate for the entire series is recorded as 23.5 per cent. The primary mortality was 1.3 per cent in a series of 285 patients; there was no primary mortality among the Group I and II cases. We feel that these figures compare very favorably with the purely surgical survival rates reported although they are inferior to the results of Lanch's combined radium and surgical procedure with the exception of his primary mortality which as previously noted was 5.4 per cent.

The foregoing statements present substantial evidence in favor of irradiation as the treatment of choice in the vast majority of cases of carcinoma of the cervix.

**Technic of Irradiation Therapy**—There has been considerable variation in irradiation technic since radium became available to the gynecologist as long ago as 1904 when Howard Kelly bought his first supply. Although the x rays were used as early as 1896 in the treatment of cancer it was not until after radium therapy had become an established method of treatment for carcinoma of the cervix that the gynecologist turned to the x ray as a supplemental measure of therapy. Two hundred kilowatt machines have largely been used but in recent years supervoltage apparatus has come into being employing anywhere from 500 to 1500 kilowatts. Lanch, Schmitz, Kamperman and others have reported improved results with the higher voltage technic combined in some way with the local use of radium; the details of which are available in many published articles.

At the Jefferson Clinic our plan of treatment has gone through several phases. From 1921 to 1931 radium was used principally, most often as a single primary application. X ray was used subsequently in some cases, most frequently for recurrence. From 1931 to 1934 roentgen irradiation was employed much more systematically following

the initial radium treatment. In 1935, external irradiation with x-ray began to be used before the application of the radium, and sometimes it was repeated after the radium as well. Since 1936, preliminary x-ray therapy has been regularly employed before the use of the radium and since 1942 a transvaginal port has been used in addition to the four external ones.

Our present plan of therapy, uniformly employed since 1942, is as follows. After clinical classification of the lesion (Schmitz), initial biopsy, cystoscopic and proctologic examinations, external irradiation is begun. Multiple ports are employed, two anteriorly and two posteriorly at first, cross firing the uterus and parametrium. Two such areas are treated daily, each receiving 200 r (measured in air). The treatments are continued until a well marked erythema is obtained which in general will occur with a total of 1600 to 2400 r to each portal. After the external portal treatment is well under way, the transvaginal port is utilized until a similar total roentgen dosage is attained. Three to four weeks are required to complete the series. This is true in most instances when the patient's residence requires hospitalization, when the time element is not restricted, and to reduce irradiation sickness, the treatments are carried out over a longer period with reduction in the daily roentgen dosage. The factors now employed are 25 ma at 200 kv, filtered through 0.5 mm or 1.0 mm of copper and 1.0 mm of aluminum at 50 cm skin-target distance, ports 16, 19, or 20 cm square.

After two to four weeks, depending upon the patient's reaction she is returned to the hospital for radium therapy. The results are often astonishing. Even extensive lesions—friable, ulcerating and bleeding—frequently show marked regression and vaginal vault contraction. The parametrial areas often show lessened fixation and induration, pain and bleeding have lessened or are absent. Primary infection is thus greatly reduced in preparation for the use of radium.

A massive dose treatment with radium is then given. Two or three 50 mg capsules of radium, each screened with 1.5 mm of platinum enclosed in rubber tubing, are arranged in tandem in the uterine cavity and cervical canal according to the number that can be accommodated as an intracavitary application. Then ten 10 mg needles, 2 cm active length, each screened with 0.5 mm of platinum, are placed interstitially about the periphery of the growth, at the junction of the supposedly involved and sound tissue. Each radium element used is attached individually by stout fishing tackle string to a narrow gauze strip which is firmly packed into the vagina and fornices thoroughly displacing the radium contained tissue away from the normal vaginal epithelium, the bladder and the rectum thus increasing the distance between the radium and these structures. In addition, a retention catheter is placed in the bladder to keep it empty and further removed from the radium. For the catheter is attached to a drainage tube and

urinary reservoir. An average dosage of 4500 to 5000 mg.-hr. is given. Nearly all Group IV patients, and occasionally Group III patients, are subjected to x-ray therapy only.

After a brief period of convalescence, the patient leaves the ward and is given an appointment for a subsequent examination in the Cancer Follow-up Clinic of the Gynecological Out-patient Department. This is an integral part of the General Tumor Clinic. After that, the follow-up visits are spaced as seems necessary. Contact with the patients is kept up relentlessly by cooperation with the family doctor, if there is one; by letters and visits to patient and relatives. The clinic is held weekly, with an attendance varying from two or three to ten or twelve.

We do not hesitate to reirradiate for recurrence, but only after another biopsy. Postradiation reactions in the vaginal vault, bladder or rectum are sometimes deceiving. In the past, when only radium was employed, local recurrences were not infrequently seen; 35.7 per cent of our five-year survivors, alive from five to nineteen years in 1942, had received reirradiation during that observation period. This phase of treatment has not been employed nearly so frequently since the adoption of our present plan of preliminary x-ray therapy.

Irradiation therapy has its serious complications, but they occur most frequently in Group III and IV patients—patients who would undoubtedly have done badly in any event. Varying degrees of irradiation sickness and skin reactions may occur. Pathologic fractures have been ascribed to x-ray therapy. Renal involvement is most common, due to constriction of the ureters by unarrested carcinoma rather, perhaps, than by postradiation fibrosis. Cystitis and proctitis are not rare, but usually are self-limited unless accompanied by malignant invasion. Vesicovaginal and rectovaginal fistulas are probably caused just as often by advancing malignant disease as by irradiation. Most disturbing of all is intestinal obstruction, due sometimes to postradiation adhesions. Patients presenting evidence of this complication should be treated promptly, for lives can be saved by surgery in those instances where no extension of the malignant growth has involved the intestines, and where any obstruction simply due to adhesions may possibly be overcome by decompression, resection or colostomy. Intractable pain may sometimes necessitate presacral neurectomy or phordotomy, if less formidable methods of relief fail.

**Carcinoma of Cervical Stump.**—The incidence of carcinoma of the retained cervical stump following supravaginal hysterectomy is difficult to estimate, but it is perhaps in the neighborhood of 1 per cent. In relation to carcinoma of the cervix in general, however, the incidence is higher, averaging 4 to 5 per cent from collected statistics. Space does not permit of a discussion of the various factors that concern the evolution of this lesion. Suffice to say that the incidence can be reduced by meticulous examination of the cervix whenever hyster-



ectomy is to be performed, so that the proper procedure suitable to that particular individual may be carried out—whether it be total hysterectomy or the correction of any abnormal cervical lesion coincidental with the supravaginal procedure. The consensus, with which I am in accord, is that cervical stump cancer is best treated by irradiation according to the technic previously mentioned, but allowing for such individual conditions as may alter it. In the Jefferson Clinic our five year survival rate in this condition, as reported in 1942 was 50 per cent, all the patients having received irradiation therapy.

**Carcinoma of the Cervix Complicating Pregnancy**—Fortunately, carcinoma of the cervix and intrauterine pregnancy occur rarely in combination for the obvious reason that the incidence curves do not cross. The occurrence of the lesion once in 10,000 times is an acceptable index of frequency. Naturally, with such a rare lesion, personal experience is at a minimum, especially when the question of treatment is considered, but this should not be true of early recognition. If the same diligence is exercised in the investigation of vaginal bleeding occurring in the course of pregnancy that is, or should be, utilized in the study of abnormal bleeding as a gynecological problem, the discovery of this complication need not be overlooked.

Slight or moderate bleeding making its appearance in the pregnant state is probably due to the well known causes ascribed to it, but one should never hesitate to make a thorough inspection with aseptic caution. No harm of consequence can result from the biopsy of a suspicious cervical lesion if adequate care and gentleness are employed.

It is our belief that the management of the carcinoma should have precedence over the possibility of securing offspring. This view may not be favored by the mother, in that event, her wishes must be taken into consideration and action planned accordingly. The state of advancement of the pregnancy has a great deal to do with what is best or desirable. As has been intimated, individual experience is limited, it is only by pooling the knowledge and expressed ideas of others that rational plans of therapy can be suggested. J. L. Baer has done that and in convincing fashion. We are practically in agreement with everything he says, and quote his views liberally.

When a lesion is discovered during the first trimester, prompt internal and external irradiation had better be instituted. By causing death of the fetus spontaneous abortion will probably occur or evacuation can be performed in due time. Meanwhile the malignancy will be under attack. No one would find fault with the able operator who would elect the Wertheim procedure in preference to irradiation should the carcinoma be a truly early one, but external irradiation should be employed subsequently.

When carcinoma is found during the second trimester, and as viability is approached, combined irradiation with x ray and radium would be in order, if the lesion is a moderate or well advanced one. Here

again death of the fetus may result in spontaneous abortion. Should this not happen, then supravaginal hysterectomy may be performed in four to six weeks, or a simple panhysterectomy instead, with adnexal extirpation in either case. If maintenance of fetal life is insisted upon, moderate radium dosage might curb the lesion temporarily, permit intrauterine life to continue, and a viable infant could possibly be secured by Porro cesarean section, after which irradiation therapy could be resumed and completed.

Should the cervical carcinoma be discovered late in pregnancy or when labor has commenced, the immediate problem becomes an obstetrical one. If the patient is a multipara, she may deliver spontaneously, but the degree of damage from hemorrhage, trauma and sepsis presents a definite risk. After delivery, complete irradiation therapy can then be instituted. This has been our personal experience with two patients, one is living and well fourteen years after the event, but the other, similarly treated, died of unarrested disease within two years. These patients were not seen by us in the antepartum period. Should delivery from below be impossible or inadvisable, then Porro cesarean section is indicated with subsequent irradiation rather than panhysterectomy, either simple or radical, even though the lesion be a seemingly early one. J. P. Greenhill, however, points out the potential damage to the fetus following irradiation therapy when intrauterine death does not result primarily.

**Summary**—One often wonders then why a supposedly early case does not respond well to irradiation, that death from general carcinomatosis may occur within a short time thereafter, indicating early involvement of the regional nodes, as well as rapid recurrence or unarrest of the local lesion. The answer may be that the response to irradiation is very probably dependent not only upon the biologic processes that are constantly going on in all the tissues within the range of treatment, but also to an appreciable extent upon the age and physical status of the patient. The amount of irradiation administered must also be taken into consideration.

It must be remembered that radiosensitivity is relative, and that radiocurability is not an equivalent term. It is unfortunate that one cannot prognosticate from the microscopic gradation of the biopsy specimen. Such grading is of importance in prognosis and sensitivity to irradiation only if closely correlated with the history, gross character and clinical interpretation of the lesion, for it is clinically true that growths of low grade malignancy may prove to be as radiosensitive as is tissue of high grade malignancy. The reaction to irradiation may be entirely different in neoplasms that are seemingly of the same histologic type. Healy and Cutler have expressed their belief that satisfactory surgical results decrease proportionately with increased tumor malignancy and that increased sensitivity to irradiation is exhibited by the more anaplastic growths. Such an observation may be

of some prognostic significance, but it cannot be relied upon in cervical carcinomas. As stated earlier in this article, a more likely assumption is that prognosis depends to a far greater extent upon the clinical characteristics of the lesion and its subsequent response to irradiation than upon the controversial factor of a change in cytologic structure as observed in serial postradiation biopsies. Interesting studies of this sort have been published by Stewart and Farrow, D G Morton, C C Norris, S Warren and others. With respect to carcinoma of the fundus, on the other hand, clinical observation does suggest that cell type bears a more distinct relationship to therapy and prognosis, as will be noted later.

In brief then, I state unhesitatingly that in the opinion of the majority of gynecologists, carcinoma of the cervix in the vast majority of cases is treated better by irradiation than by surgery, either alone or in combination with irradiation, except in exceptional instances.

#### CARCINOMA OF THE FUNDUS

**Diagnosis.**—Carcinoma of the uterine fundus presents a somewhat different picture in diagnosis than does cervical carcinoma. Generally speaking, it is rare to find carcinoma in this location before the age of forty. It is essentially a disease that becomes evident at any time after the cessation of the periodic bleeding that is usually regarded as being coincident with the menopause. In other words, postmenopausal bleeding always suggests carcinoma of the corpus. Contrasted with carcinoma of the cervix, it presents the problem of concealed bleeding for in most instances the cervix is either atrophic, intact, or merely exhibits a minor degree of endocervicitis, bleeding from this site is usually absent. In the Jefferson Clinic, postmenopausal bleeding has been present in 78.7 per cent of all the patients in our fundal carcinoma series, the average age of the group being 59 years. Among those patients experiencing no definite cessation of menses (21.3 per cent) the average age was 46 years. It may be stated generally, therefore, that irregular uterine bleeding, or "spotting" as it is so commonly called, is almost invariably the initial symptom of endometrial carcinoma, particularly if it occurs as a postmenopausal manifestation. In only 4 per cent of our series has this symptom been absent.

Benign conditions may be responsible for this symptomatology. Senile vaginitis, cervical and endometrial polyps, so-called fibrosis uteri (metropathia haemorrhagica), cardiovascular disease and even fibromyoma or pelvic inflammatory disease, may be among the offending lesions. Of serious import is uterine bleeding due to ovarian and tubal malignancy. Bearing in mind the symptomatology presented, it becomes evident that the diagnosis must be made by exclusion and in this respect curettage is the most reliable diagnostic procedure. What has been said previously with regard to the Papanicolaou vaginal smear method of diagnosing carcinoma of the cervix holds good in its appli-

cation to fundal carcinoma, viz., that its chief value lies in calling attention to the possibility of cancer being present within the uterine cavity, the existence of which may be suggested by this very intriguing technic before the classical symptoms become evident. In the final analysis, however, it is the curet that furnishes the most acceptable evidence. Routine curettage of the endometrium, as a matter of record, is a valuable accompanying procedure when vaginal plastic operations are performed, just as routine cervical biopsy and histologic examination of removed cervixes is. Carcinoma of the fundus in postmenopausal patients will rarely be overlooked, if the possibility of the condition is always borne in mind and diagnostic curettage resorted to promptly.

The diagnosis is most frequently missed in women of the younger age group (40 to 50), in whom periodicity of menstruation has not ceased, or in whom menorrhagia and/or metrorrhagia are the symptoms complained of. The association of fibromyoma and endometrial carcinoma is well known. Too often menorrhagia and metrorrhagia are ascribed to the presence of the fibromyoma found upon examination and an inadequate plan of treatment results. Again, injudicious endocrine therapy may be employed, often without a pelvic examination of any sort, and valuable time is lost thereby not only from the standpoint of diagnosis but because of the delay in instituting indicated radiological and surgical treatment. The same situation exists with regard to estrogenic therapy for the vasomotor symptoms incident to the menopause. Natural and synthetic estrogens frequently produce postmenopausal bleeding, and a confusing diagnostic picture results. In such cases the gynecologist must invariably resort to diagnostic curettage, to prove or disprove the presence of endometrial cancer. We have called attention in a recent publication to this ever-increasing danger, as a factor in the delayed diagnosis of both cervical and fundal carcinoma, and others have sounded similar warnings.

Proper evaluation of the curetings is of equal importance with the indications for the procedure, and the gradation of the tissue is of more positive value with regard to treatment and prognosis than is the case with cervical biopsy. That is because surgery plays such an important part in the management of the patient with fundal carcinoma and this phase of the problem is best discussed in that category. Suffice to say that the pathologist who is well trained in gynecologic pathology is of inestimable help clinically in determining the course to be followed, once the diagnosis of fundal malignancy has been established.

**Management**—For a long time the treatment of fundal carcinoma was regarded as a purely surgical procedure, i.e., panhysterectomy with removal of both adnexa. The success that attended the irradiation therapy of cervical carcinoma led many gynecologists to attempt to secure similar results with radium and/or x-ray therapy. In such

instances it was soon noted that, after an apparent "cure," recurrence or unarrest of the lesion was evidenced by a return of the symptoms even after an interval of five years or more. It was also observed that in patients solely treated by surgery, local recurrence in the vaginal vault, as well as pelvic and distant metastases, occurred too frequently within a relatively short time. Unfortunately, too, the performance of supravaginal hysterectomy for fibromyoma sometimes reveals an unsuspected endometrial cancer that has already invaded the retained stump, with subsequent pelvic recurrence. In some instances, also the subtotal operation has been chosen deliberately as the plan of procedure in fundal carcinoma, an unwarranted and illogical procedure.

All of these factors have led to the modern conception of the proper therapy for fundal malignancy, which is rather widely accepted at the present time, viz., a combined method, employing both irradiation and surgery. It is uniformly recognized that patients with corpus cancer, since the vast majority fall into the older age groups are oftentimes substandard surgical risks, because of extreme age, cardiovascular disease, renal impairment, diabetes, and so forth. This means that individualization of the patient with suspected fundal carcinoma is not only desirable but necessary.

Few, if any, of the leading clinics today treat the average patient solely with surgery or solely with irradiation, except where individual selection has made either one method or the other imperative. Most frequently, the two are used in combination, usually preceding the surgery with radium and/or x ray, and following the operative procedure with x ray in some instances. The management of fundal carcinoma in vogue at the Jefferson Clinic is fairly representative of the methods used in the leading clinics throughout this country. While certain variations in technic occur, space will not permit of an intimate discussion of these differences which, after all, do not vary appreciably in principle. I shall, therefore, restrict my remarks to the technic evolved in the Jefferson Clinic since its inception in 1921.

In the earlier days of our experience, or until approximately 1929 patients were generally treated either by surgery alone or by irradiation alone, and in the latter instance the majority of those treated received radium only. Repetition of treatment with irradiation was not unusual, however. Because of the relatively low survival rate of those patients treated solely with surgery, the plan of treatment was gradually changed, preliminary irradiation with radium being employed increasingly before surgery was attempted. This so improved the survival rate that since 1937 this newer therapy has been the procedure of choice more and more often. X-ray therapy after either radium or after surgery preceded by radium, is not used routinely, but each patient is individualized in this respect. A five year survival rate of about 40 per cent, reported in 1943 and averaged on all methods of treatment, has now been increased to approximately 50

per cent since the present plan of treatment has been more consistently followed. Norman Miller, G. Van S. Smith, G. G. Ward, and W. P. Healy have had a similar experience, some with even better survival rates. Miller's results (82.3 per cent) are outstanding. He employs x-ray rather than radium as a preliminary step. J. Heymann of Stockholm, long an ardent advocate of irradiation only, stated some time ago that he no longer excluded surgery in preference to irradiation.

Carcinoma of the fundus presents a wide variation in the histologic picture. In the Jefferson Clinic, we recognize the following gradation with regard to the malignancy exhibited:

- 1 Low grade (corresponding to papillary adenoma malignum and adenoma malignum—Grades I and II)
- 2 Intermediate grade (corresponding to adenocarcinoma—Grade III)
- 3 High grade (solid cellular, or diffuse anaplastic adenocarcinoma—Grade IV)
- 4 Adenoacanthoma

It is not always easy to determine the grade of malignancy in every case, for sometimes the histologic picture is a varied one. Neither, as is the case with carcinoma of the cervix, can specific conclusions be arrived at with regard to prognosis from cell type. While low grade lesions seem to respond equally well to irradiation and surgery, it has been our experience that the survival rate in intermediate and high grade lesions is much more likely to be improved when irradiation has been a factor in the treatment, either singly or in combination with surgery. The adenoacanthoma, a rare histologic picture, varies considerably in its degree of malignancy and response to treatment.

When a patient with postmenopausal bleeding is seen in the Jefferson Clinic, our first concern is to exclude endometrial cancer. This is accomplished by prompt diagnostic curettage and two 50 mg capsules of radium, each screened with 1.5 mm of platinum, are arranged in tandem, enclosed in rubber tubing and placed in the uterine cavity, so that the end of the rubber tubing is flush with the external cervical os. It is securely attached to narrow gauze packing which fills the vagina and a retention catheter is generally placed in the bladder to keep it empty. A report on the curettage is furnished in four hours by an especially rapid staining technique. If malignancy is present, a dosage of approximately 5000 mg-hr is given. Otherwise, dosage suitable for a benign condition, such as metropathia haemorrhagica, is employed. Sometimes, if the uterine cavity is larger than usual, three radium capsules are used. Naturally, the amount of good that the radium does depends upon the efficacy of application. Tortuosity of the cavity and sessile elevations will interfere with effective irradiation, as Sampson and others have proved. If there is no fixation of the uterus and no suggestion of adnexal involvement, abdominal panhysterectomy and bilateral salpingo-oophorectomy are carried out six to eight weeks later, if there is no definite contraindication to surgery.

Otherwise, x-ray therapy follows the radium application and some times the latter is repeated later on. We do not assume that the preoperative irradiation will eradicate the disease, but we feel that it devitalizes the growth, prevents its dissemination and lessens the chances of local recurrence if and when surgical removal can be effected. Local infection is also diminished. Postoperative x-ray is used only if there is visual or palpable evidence of pelvic extension at operation.

We believe, however, that irradiation offers much to the patient *whose condition will not permit of subsequent surgery*. This belief has been fortified by finding that in 50 per cent of uteri removed after preliminary irradiation, histologic sections have shown an absence of the preexisting carcinoma. This knowledge holds out much hope for the patient whose physical condition denies her surgery. Gratifying five-year survivals have been reported in this group of patients by Fricke and Bowing and by the other workers previously mentioned.

Occasionally, a preliminary radium treatment is impossible or inadvisable. This is sometimes true of patients in the premenopausal age group (40 to 50), who are host to fairly large fibromyomas, and in whom it may well be assumed that the symptoms are caused by them. In such instances, bearing in mind the well-known association of fibromyomas and endometrial cancer, it is perhaps better to do an immediate panhysterectomy, and inspect the uterine cavity after the uterus has been removed, before allowing the adnexa to remain in situ, or a preliminary curettage can be done, a frozen section examined, and the necessary pelvic surgery proceeded with at once.

**Summary**—Our conviction is that every patient who can possibly "stand operation" should have the benefit of surgery after preliminary irradiation. The fact that in our recently reported series, residual carcinoma was present in half the removed uteri, confirms our feeling in this respect. We have been so impressed with the increasingly improved results secured in our clinic by the technic mentioned, that I cannot endorse it too highly as the best modern treatment for carcinoma of the fundus. The majority of my colleagues feel similarly about this problem, we do not regard irradiation therapy and surgery as competitors—they supplement each other as experience has shown.

#### SARCOMA OF THE UTERUS

Sarcoma of the uterus has been estimated to constitute approximately 3 per cent of uterine malignancies. It occurs more frequently in the body of the uterus than in the cervix and is classified as either primary or secondary, being of connective tissue origin.

Primary sarcoma springs from the stroma of the endometrium or the cervical mucosa although it may have its origin in the uterine wall itself.

Secondary sarcoma results from a malignant transformation that occurs in fibromyomas the incidence of such change varying from

1 per cent or less to as high as 5 and 6 per cent. Similar malignant change may run even higher in polypi. Sarcoma botryoides is a peculiar type of growth seen occasionally in the adult cervix, in infants and young children a similar lesion is more often of vaginal origin.

The diagnosis is difficult and not often made preoperatively, neither is it a simple matter to decide accurately whether the growth is primary or secondary. Many times it is unsuspected until the pathological report is received from the laboratory. A metastatic lesion may be the first evidence of uterine sarcoma.

Sarcoma of the cervix can be differentiated from carcinoma only by biopsy, and the treatment in such cases is by irradiation, but the prognosis is poor. A curettage that reveals sarcoma usually means a gross lesion in the endometrial cavity or massive invasion from the uterine wall—also indicative of a hopeless prognosis.

A rapidly growing uterine tumor having the palpable characteristics of a fibromyoma, and giving rise to profuse bleeding, should be regarded as possibly being sarcomatous. Curettage, in such an instance, may furnish positive evidence in a frozen or rapidly prepared histologic section, and if the uterine cavity will accommodate the capsules, an adequate radium dosage, supplemented by x-ray therapy, can be employed prior to panhysterectomy with bilateral adnexal removal. A sarcoma such as this is likely to be a primary one, and the prognosis should be guarded especially if the mitotic figures are plentiful, as pointed out by Kimbrough.

More commonly, however, the lesion is a secondary one, revealed when the "myomatous" uterus is sent to the laboratory. Such tumors vary widely in their structure and malignant characteristics. If the hysteromyomectomy has been a supravaginal one, with or without adnexal conservation, the outlook is dubious because of possible involvement of the retained structures. In such instances, postoperative irradiation, with radium applied to the cervical stump and x-ray therapy to the pelvis, is imperative. Total hysterectomy obviates such a possibility of course, and should be selected if there is any suspicion of sarcomatous change, just as in the case of suspected cancer of the endometrium complicating fibromyoma. Following total removal of the uterus it is well to incise it immediately, and if there is gross evidence of degenerative or malignant change in the myoma or myomas present, the adnexa should be removed also. All these measures insure the better prognosis that secondary sarcoma offers.

When cervical or uterine polypi are removed, curettage should always accompany the procedure, and it is well to have radium available for intrauterine application at the same time, if the age of the patient and the character of the curettage indicates its use. All uterine polypi should be examined histologically because of the possibility of malignant change in them. Their removal as an office procedure should be discouraged for the reasons just mentioned.



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# NONMALIGNANT TUMORS OF THE UTERINE CORPUS

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THERE will be discussed here leiomyomas of the uterus (fibroids, fibromyomas, myomas) and adenomyomas (adenomyosis, internal endometriosis). The basis for discussion is analysis of 1166 cases admitted to the Philadelphia Lying-In Hospital in the years 1935 to 1944 inclusive primarily for tumor, not including late pregnancy, and selected articles from recent literature.

## LEIOMYOMA OF THE UTERUS

**Relative Incidence**—Among 9969 private and ward gynecological patients discharged from the Philadelphia Lying-In Hospital a total of 7679 operations were performed, including 1046 surgical procedures for fibroids. Williams<sup>1</sup> reports from the wards (70 per cent Negro) of the Philadelphia General Hospital in a similar ten year period 14,104 gynecological admissions, of which an extremely high number were for septic abortion and pelvic inflammatory disease. In this group 6372 operations were done, with 1405 hysterectomies for uterine tumor, among which were a few uterine body cancers. Levy,<sup>2</sup> of Louisiana, reports that of 5821 patients operated upon for fibroids over a ten year period 87.7 per cent were Negro and 12.2 per cent white women, from 59,324 gynecological admissions of nearly equal white-colored ratio to Charity Hospital. It is obvious from these figures that myomas are much more common in colored than in white women.

**Etiology**—Subserous uterine and extragenital fibroids can readily be produced in guinea pigs by estrogens,<sup>3</sup> and prevented by steroid hormones (adrenal cortex, progesterone, testosterone). Functional cause (hyperestrinism) is also suggested in women by the high incidence of nulliparity, very common one child (pelvic inflammatory disease) sterility in Negroes, the large amounts of urinary estrin<sup>4</sup> and increased endometrial hyperplasia that have been reported, and the involutionary effect of androgens (see "Treatment"). However, in spite of frequently associated cystic ovaries, Brewer and Jones<sup>5</sup> in 100 cases of fibroids proved normal corpus luteum function, and found cystic endometrial hyperplasia in only one case. Henderson<sup>6</sup> reports accompanying hyperplasia in only 6.5 per cent of cases (our series slightly higher), and Levy<sup>7</sup> reports menometrorrhagia in only one third of his cases of fibroids, and this was chiefly due to polyps and submucous tumors rather than to hyperplasia.

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**Diagnosis**—If the patient is over twenty-five years of age and still in the childbearing period, has a marital introitus and shows abnormal bleeding and uterine enlargement, the possibility of pregnancy will of course be considered and the symptoms and signs carefully checked. If there is any doubt, a biologic test (Friedman, frog, Aschheim Zondek or other) must be completed. In addition, external-internal prolonged bimanual uterine palpation may disclose pregnancy uterine contractions and in questionable instances where the enlargement is the size of thirteen weeks' pregnancy or over, an x ray film for pregnancy is indicated, bearing in mind the possibility of combined pregnancy and myoma.

Unless submucous, thereby causing increased frequency and amount of menstruation, small fibroids are usually asymptomatic and discovered in the course of routine examination. Abnormal bleeding calls for a diagnostic dilatation and curettage including uterine exploration with a polyp forceps, for possible pedunculated myoma, endometrial polyps and cancer, plus conization or needle coagulation (and biopsy) for erosion.

Larger myomas will produce pelvic pressure or impaction discomfort due to degenerative changes especially liquefaction necrosis and inflammation, in which case tenderness and softening will be found. Differentiation between gross myomatous degeneration and extensive tubo ovarian suppuration can readily be made except possibly in Negroes in whom both processes should be assumed.

In pregnancy, abortion is more frequent, more often hemorrhagic and incomplete, and tumors will enlarge, may become edematous, but will usually regress rapidly. Localized pain frequently means red degeneration, with some fever or leukocytosis<sup>7</sup> which is more common in the puerperium (see "Treatment").

In extremely obese women, iodized oil hystero-graphy, with the oil injected directly or indirectly into an intrauterine rubber balloon<sup>8</sup> will usually show irregularity of the uterine cavity. The direct method is facilitated by a new cervical tenaculum,<sup>9</sup> or by Colvin's or Hudgin's new screw-tip cannulas<sup>10</sup> which require no tenaculum. Transabdominal pneumoperitoneum roentgenography<sup>11</sup> will outline the exterior uterus and differentiate ovarian tumors, tubal enlargements and adhesive masses. Contraindications to pneumoroentgenography are age and weakness, and large pelvic masses, and to hystero-graphy, the above plus possible pregnancy, uterine bleeding, purulent discharge and inflammation.

**Treatment**—1 **CHILD-BEARING AGE**—Small to moderate (under the size of a twelve weeks' pregnancy) asymptomatic fibroids require only semi annual observation, since they do not predispose to other general or local diseases (including uterine carcinoma), and since sarcomatous metaplasia is rare, usually circumscribed isolated and microscopic (in the Philadelphia Lying-In Hospital 0.68 per cent).

Rapidly growing, symptomatic, or large tumors should be removed by one of the following procedures

(a) *Myomectomy*—Vaginal or abdominal removal of the myomas should be chosen whenever possible, and is suitable for all pedunculated and subserous tumors and many large intramural and submucous growths, without sacrificing menstrual or reproductive function. Even multiple, fairly large tumors may be removed through a few carefully chosen uterine incisions.

Miller<sup>10</sup> advises myomectomy in 10 to 15 per cent of cases of operable myomas in a private practice, expecting recurrence in only 3 per cent. Rubin<sup>12</sup> warns of the dangers, advising operative use of an elastic tourniquet above the cervix to prevent hemorrhage, and meticulous peritonealization by means of vesico-uterine and anterior parietal peritoneum, sigmoid epiploica and omentum so that mortality does not exceed 1 per cent. Preoperative hysterography not less than six weeks before operation, and/or dilatation and curettage at operation for possible polyps and cancer are necessary precautions.

Rubin reports thirteen term pregnancies from twenty-five conceptions following 481 myomectomies, and Miller<sup>14</sup> 36.5 per cent pregnancies after 141 myomectomies, among which were three microscopic sarcomas not requiring irradiation. These authors, Phaneuf,<sup>15</sup> and others consider unlikely rupture of the uterus in subsequent labor. Mussey, Randall and Doyle<sup>15a</sup> report 135 term births from 167 total pregnancies in 101 women after 250 myomectomies.

*Fibroids and Pregnancy*—Among 4000 pregnancies in white ward patients in Preston Retreat, I found only three sizable myomas, none of which interfered before, during, or after labor. The general incidence in pregnancy is reported as 0.03 to 0.7 per cent but is much higher in Negroes. Da Costa<sup>16</sup> reporting 1.5 per cent.

Severe symptoms from torsion, necrobiosis (red degeneration), hemorrhage, uterine incarceration and compression will require relief, preferably by myomectomy. Large symptomatic myomas that are deep or intraligamentary must be removed by supravaginal hysterectomy. In the Philadelphia Lying-In Hospital only two abortions resulted from ten myomectomies, but in twenty-seven pregnancies complicated by myomas hysterectomy was necessary.

Cesarean section is indicated in the presence of very large, deep tumors to forestall ineffectual labor contractions as well as fetal malposition for which external version is usually impossible and internal podalic version as well as breech decomposition is unsound, and for very low fibroids to avoid birth obstruction. Incidental myomectomy at cesarean section is not safe for sizable deep, intraligamentary or numerous tumors, which should either be left for late removal or removed by Porro cesarean section depending on the age of the patient, number of children, and prospects of postpartum hemorrhage, puerperal necrosis or infection.<sup>17</sup> Puerperal myomectomy is especially



dangerous, although puerperal hysterectomy must be done occasionally for necrosis or hemorrhage after excluding puerperal sepsis

(b) *Supravaginal Hysterectomy*—In the childbearing age, symptomatic fibroids that are too numerous or too large for myomectomy must be removed with the uterus. If gross inflammatory residues (old pus tubes," etc.), extensive endometriosis, extreme obesity, excessive adhesions or bleeding materially complicate the operation, then the cervix should not be excised, in spite of a 1 per cent possibility of future cervical stump cancer.<sup>18, 19</sup> Cervical conization for cervicitis is usually combined with supravaginal hysterectomy, but occasionally results in postoperative morbidity, so that some gynecologists prefer to postpone attention to the cervix for six weeks or more.

(c) *Fundusectomy*—For preservation of menstrual function where childbearing is unsafe for any reason and fundal myomectomy with tubal ligation resection (Pomeroy) sterilization is inadvisable, this procedure, known as the Bell-Beutner operation, which includes salpingectomy and relocation of the round ligaments, is particularly suitable for diffuse fibrotic enlargement of a posterior uterus.

(d) *Total Hysterectomy*—Symptomatic fibroids in the childbearing period, unsuited for myomectomy (qv) and without technical complications (see Supravaginal Hysterectomy) should be removed by total hysterectomy. Following this operation there is no vaginal shortening, no greater risk for trained gynecologists, no less ovarian function, no less support with or without vaginal repair, no bleeding as from high supracervical amputation, and no postoperative cervical stump disease. Consequently, with the advantages of continuous spinal anesthesia, there is increasing preference for total hysterectomy. Although morbidity is less, one must not be misled by reports of less mortality than with the supravaginal method, the reason being that the latter operation is usually chosen for "poor risks." Menzert and Stoltz<sup>19a</sup> at the University of Iowa describe a simple technic of total abdominal hysterectomy in 1925 cases, with a mortality of only 0.94 per cent among the latter half of the cases.

2. *MENOPAUSAL AGE*—Small asymptomatic myomas should be observed regularly with the expectation of spontaneous involution. Testosterone propionate therapy has produced uterine atrophy as well as control of associated nocturia,<sup>20</sup> functional bleeding, menopausal instability and failing libido, in maximal dosages of 600 mg orally or 700 mg intramuscularly per month, or 25 to 145 mg in pellets implanted subfascially.<sup>21</sup> Such therapy is expensive, temporary and arrhythmogenic.

(a) *Radium Irradiation*—Radium has a limited application but is ideal for relatively small (under the size of a twelve weeks' pregnancy), bleeding, nonpedunculated (external or internal), painless, insensitive, uncomplicated intramural myomas. In the Lying-In Hospital only forty-nine out of 1026 surgically treated fibroids (4.8 per

cent) received radium, and two of the patients died of advanced cancer. Seventy-five milligrams of radium equally divided in three platinum tandem capsules sheathed with rubber, introduced completely within the uterine cavity for twenty-four hours (1800 mg.-hours) was sufficient in all but one case, which required eventual hysterectomy. Dilatation and curettage, endometrial biopsy and search for polyps must precede irradiation and conization or coagulation and biopsy are essential for erosion.

TABLE 2—UNFINISHED OPERATIONS (19) FOR 1166 LEIOMYOMAS OF THE UTERUS, PHILADELPHIA LYING-IN HOSPITAL

(Showing No Deaths from Operations Not Completed for Various Causes)

Exploratory abdominal section	8
Excessive adhesions	6
Hemorrhage	1
Pregnancy	1
(Myomectomy in 4 cases)	
Appendectomy and Papanicolaou sterilization	1
Spinal anesthesia shock	1
Plastic repair only	4
Ectopic pregnancy	5
Deaths	0

TABLE 3—NO OPERATIVE TREATMENT (121) IN 1166 LEIOMYOMAS OF THE UTERUS, PHILADELPHIA LYING-IN HOSPITAL

(Showing Causes for Postponed or Impossible Operations)

X-ray irradiation	5
Medical complications	25
Surgical complications	3
Gynecological complications	88
Acute pelvic inflammation	17
Lymphopathia venereum	1
Threatened abortion	2
Abortion	28
Postpartum	2
Refused operation	14
Mild symptoms	13
Sterility	5
Pregnancy	6
Deaths	0

(b) *Hysterectomy*—Symptomatic, large or rapidly growing myomas in the menopausal age should be removed by total hysterectomy including bilateral salpingo-oophorectomy. Myomectomy and fundus ectomy are contraindicated but if (rarely) conditions previously mentioned preclude total extirpation, supravaginal hysterectomy may be done, provided the uterus and adnexa are inspected for cancer. In any difficult or complicated hysterectomy, "prophylactic" or routine appendectomy is unwise.

(c) *Vaginal Hysterectomy (Total)*—For small to medium fibroids with marked prolapse, cystocele, rectocele and cervicitis, especially in obese or debilitated women, this procedure is safer and quicker, even with extensive repair. The operation is not practicable in the presence of many pelvic adhesions or extensive adnexal disease.

In Philadelphia, Kennedy<sup>1a</sup> has popularized the clamp method, and Averett, Babcock and others the suture technic. Tyrone and Weed report a mortality of only 0.65 per cent from 305 vaginal hysterectomies for various causes, and Danforth<sup>2a</sup> reports no deaths from 170 vaginal hysterectomies for fibroids.

(d) *X-ray Irradiation*—Only five out of our 1166 listed myomas were treated by x-ray alone (0.43 per cent), the chief indications being very large bleeding tumors, inoperable by reason of excessive adhesions (three), hemorrhage at attempted operation (one), and medical complications (one). Preliminary dilatation and curettage to determine the presence or absence of cancer is essential.<sup>34</sup>

3. *POSTMENOPAUSAL AGE*—Thyroid or estrogenic hormone therapy may cause bleeding with fibroids, otherwise metrorrhagia suggests an accompanying uterine cancer, a submucous or pedunculated myoma, ovarian granulosa cell "carcinoma," or hematomata due to cervical stenosis from conization. The uterine sound, gynecography, culdoscopy<sup>35</sup> (pelvioscopy), posterior colpotomy and dilatation and curettage will certainly prove the possibilities and indicate the treatment. I have recently removed an atrophic uterus from a 59 year old patient following free bleeding due to a small submucous myoma which had been unsuccessfully treated by radium thirteen years after the menopause.

X-ray and radium, and myomectomy (except for pedunculated symptomatic myomas) are contraindicated, leaving total internal genital extirpation available for bleeding or sizable tumors with or without symptoms. Total vaginal hysterectomy under deep fractional morphine scopolamine narcosis with or without local anesthesia<sup>36</sup> is ideal for elderly women.

#### INTERNAL ENDOMETRIOSIS

*Relative Incidence*—Internal endometriosis occurs in three forms: (1) adenomyoma, or circumscribed nodular tumefaction of the myometrium consisting largely of endometrial glands which cannot be shelled out as can a myoma, (2) adenomyosis or diffusion of endometrial stroma cells through the myometrium,<sup>37</sup> and (3) endometriosis interstitialis (Goodall) usually in the form of a soft mass of spindle cell stroma resembling a submucous myoma.<sup>38</sup> In addition to the three internal types, serosal bluish nodules of parametrial external endometriosis usually with tubal, ovarian or large bowel<sup>39</sup> involvement are common, although of different origin and behavior.

Unfortunately the above terms are often used loosely, so that re-



ports are confusing. It is definite that internal endometriosis occurs later in life than the external type, is frequently associated with myomas, is relatively uncommon in ward practice and rare in association with extensive pelvic inflammatory disease.

Meigs<sup>30</sup> reports histologic endometriosis of various types in 28 per cent of 400 private patients undergoing operation, Holmes 26 per cent of 307 patients submitting to laparotomy, the Mayo Clinic<sup>31</sup> 2062 diagnosed cases in a twenty year period. Frank and Geist<sup>32</sup> found twenty-three menopausal women among 203 with adenomyosis, and Dannreuther<sup>33</sup> thirty-nine instances of adenomyosis with ten of adenomyoma, among 115 cases of endometriosis. Our Lying In series charts internal endometriosis sixty times and external eighty times among 1076 operated fibroid tumors.

**Etiology**—In addition to possible mechanical predisposing causes such as uterine myomas, posterior uterine displacement and cervical atresia, I believe the exciting cause to be hormonal, i.e. hyperestrinism. Clinically this is suggested by frequently associated deferred child bearing and pathologically by a greater incidence of endometrial hyperplasia (25 per cent) than with fibroids.<sup>6</sup>

**Diagnosis**—Acquired dysmenorrhea and/or abnormal menstrual flow with soft uterine enlargement in a nulliparous woman near forty, are suggestive. Exclusion of inflammation, fibroids (q.v.) and malignancy makes a presumptive diagnosis of internal endometriosis, with which may be associated periodically varying painful nodules of the external type (vagina, cul de sac, uterosacral ligaments, adnexa, etc.). A hystrogram showing occlusion of the proximal tubal extremities is very suggestive of adenomyosis of uterus, tubes or both.

**Uterine Adenomyosis and Pregnancy**—Sterility with endometriosis is nearly 50 per cent relative and over 30 per cent absolute, but rare cases of adenomyosis with pregnancy have been reported, including rupture of the uterus, dystocia, abortion and hemorrhage.<sup>33</sup>

**Treatment**—1. *Medical*—In 1943 I<sup>34</sup> reported two cases of striking response to testosterone propionate therapy, and since then have favorably treated fourteen more, including one case of ureteral endometriosis, four of which have been under more or less constant treatment for two to three years, without ill effects other than minimal arrhenomimetic symptoms (slight hoarseness, enlarged clitoris, slight hirsutism). The monthly maintenance dose averaged 300 to 400 mg. of methyl testosterone by mouth, following one month in which 200 to 300 mg. were given intramuscularly. Miller<sup>35</sup> reports the preoperative treatment of endometriosis by testosterone propionate to minimize risk. It is interesting to note that Abel<sup>36</sup> with heavy similar treatment succeeded in improving the general condition but was unable to cause regression of malignant disease of the female genitalia. On the other hand, androgens have been used favorably in the suppression of menstruation in pelvic inflammatory disease.

2 *Surgical*—For progressive symptoms, hysterectomy with conservation of one or both ovaries if possible is the procedure of choice, according to the principles described under 'Myoma' (Coincident hemidnexal excisions or cauterizations of small external endometrial nodules are often required. Cashman<sup>3</sup> advises hysterectomy only, with preservation of uninvolved ovarian tissue, regardless of implants (bladder, ureter, etc.) Extensive bilateral disease with adenomyosis will require total internal genital ablation.

Radium or x-ray irradiation castration should be reserved for postoperative persistence or recurrence, or for inoperable endometriosis in which prolonged androgen therapy is undesirable by reason of expense and 'masculinizing' symptoms.

### COMMENT

Preparatory to operations for both fibroids and endometriosis, Williams<sup>1</sup> emphasis of some of Polak's precautions are well worth quoting.

- 1 A complete history and physical examination
- 2 A leukocyte count of 7000 to 10,000 with polymorphonuclears 65 to 80 per cent
- 3 Hemoglobin of over 60 per cent
- 4 Normal urinalysis and adequate kidneys
- 5 Temperature of 98.6° F for forty-eight hours or more
- 6 Two or more days of complete hospital rest prior to operation
- 7 Ample sugar, fluids, milk (and gelatin or other protein, vitamin C)

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## MERITS AND A TECHNIC FOR COMPLETE HYSTERECTOMY

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SURGICAL practice has undergone extensive changes in the last twenty five years. Many operations that are now routine procedures were considered radical in 1920 and, in fact, were seldom resorted to except in those cases in which a patient's condition was so serious that any risk seemed justified in an effort to stay a morbid process. At that time, surgery was utilized frequently only as a means of saving life or for making a diagnosis. If the patient recovered, the operation was then regarded as a success. This point of view is taken now only in rare instances. In fact, the general concept of surgery has been so completely revolutionized in the past two decades that thoracic surgery, brain surgery, gastrectomies, and various other extensive organic reconstructions are being done repeatedly and successfully in clinics throughout the world.

The element of risk in such operations has been lessened to a marked degree by thorough preoperative study of the patient, from which a complete and comparatively accurate diagnosis is made. When the status of all the vital processes has been resolved, it is then possible to determine whether the condition can be corrected by reconstruction or removal of the pathological process.

I have listed here a few important correlated advances made in medical science that have brought about these changes in surgical practice:

1. A more complete knowledge of physiological processes
2. The use of fluids and necessary chemical elements to maintain physiological processes during the critical period of restoration
3. Progress of surgical technique
4. Improved types of anesthesia
5. Follow up observations of a patient after surgical procedures

The gynecologist has likewise kept pace with the advances made in medical science, and his perspective has undergone a complete change from that of twenty-five years ago. The type of surgery that he now does is much more inclusive than would have seemed necessary to his preceptors. For instance, where it is found necessary, complete hysterectomy has become a usual and safe procedure for an experienced gynecologist. This type of operation is indicated in most cases when it is deemed necessary to remove the uterus except in

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young women where the adnexa and some endometrium can be conserved

Complete hysterectomy may be done by two methods (1) through the vagina, or (2) through the abdomen. In certain instances vaginal hysterectomy is the operation of choice, especially when one is dealing with various degrees of uterine prolapse and vaginal relaxation. Complete hysterectomy can be accomplished with comparative safety by either the vaginal or the abdominal route by an experienced surgeon, unless there are unusual technical difficulties present. I have done vaginal hysterectomies for the correction of various degrees of descensus of the uterus or for vaginal relaxation when this method seemed more expedient.

#### ADVANTAGES OF TOTAL ABDOMINAL HYSTERECTOMY

In discussing the merits of complete hysterectomy, I shall confine my discussion to points which I have observed from my experience in doing this operation by the abdominal route. In my opinion, the principal advantages are

1. **It Is a Safe Method When the Gynecologist Develops and Follows a Definite Procedure**—From my own experience gained from over 200 cases in the past three years, I am convinced that this type of operation is a safe procedure, after one has developed and practiced a definite technic. A study which I recently reported of 135 consecutive operations done within a relatively short period of time has proved this conclusion. There was no morbidity or mortality reported in this study which could be directly attributed to the operation. Since this report was made there have been about seventy additional cases with only one death which was due to pulmonary embolus on the fourth postoperative day. This death could have resulted from any operative procedure and cannot be charged to this particular type of operation.

2. **All Necessary Plastic Reconstruction of the Vagina Can Precede or Follow Abdominal Hysterectomy**—Although plastic reconstruction of the vagina can follow complete abdominal hysterectomy, I prefer to do the necessary vaginal plastic operation immediately preceding the abdominal operation. The posterior vaginal repair conforms with our standard posterior colporrhaphy. The repair of the anterior vaginal wall must be approached and executed in a different manner from that of the usual anterior repair since the cervix will not be available for fixation of the parametrium or the perivesical fascia. It must be remembered that the fixation of the perivesical fascia from above will control somewhat the herniation of the bladder through the vaginal wall, and that a special type of anterior vaginal repair must be done when complete abdominal hysterectomy is contemplated. Urinary function has not been impaired following operation when dysuria was present before treatment.

3 The Cervix Is Not a Necessary Structure When the Uterus Is Removed—The cervix has no useful function when the uterus must be removed. It is a potential menace to the individual and should always be removed if the operation is to bring about the best result. Numerous clinical reports have indicated the frequency of carcinoma of the cervical stump. Scheffey, in his report from the Gynecological Department of Jefferson Hospital, observed twenty-one instances of cervical stump carcinoma in a series of 541 cases. The occurrence of carcinoma in the retained cervix would, in itself, have justified complete hysterectomy. In the past it has been the only justification for the complete removal of the uterus. This, however, does not seem to me to be the only or sole indication for the removal of the cervix when hysterectomy is necessary. My conclusion that the removal of the cervix is desirable is based upon a critical analysis of the results following complete hysterectomy. I have been interested in observing these patients to determine if the vagina has been shortened, if the vaginal secretion has been changed, if urinary function has been disturbed or if there has been any change in the inclination toward coitus.

4 Effectual Support of the Vault of the Vagina Is Secured and the Upper Pelvic Diaphragm Can Be Completely Reconstructed—An examination of the patient following operation indicates that the vagina is normally long, and that the vault of the vagina is well fixed and is supported by the parametrium and pelvic fascia. In my experience I have not observed a prolapse of the vaginal vault, nor a vaginal eversion. This, it would seem, is a logical result of the procedure used and I doubt if vaginal prolapse would ever occur if proper attention were given to fixation of the parametrium at the time of operation.

5 The Biology of the Vagina Is Normal Following Complete Hysterectomy—From a careful study of patients following complete hysterectomy, it has been observed that the biology of the vagina has remained normal. Although these studies are not complete, there has been every indication that the moisture, flora, chemical reaction and epithelium of the vagina have not been altered appreciably by removal of the cervix. I believe this observation to be very important. As a matter of fact, it should refute the concept that the cervical secretion is essential to the maintenance of normal vaginal physiology.

6 The Sexual Function of the Individual Is Adequate—Information furnished by patients after complete hysterectomy indicates that the sexual function of an individual is not impaired by this operation. These observations bear out the conclusion that, except for the impossibility of pregnancy, no ill effect should result from complete hysterectomy. Since the vagina has not been shortened or its biology changed by removal of the cervix, it should be adequate as an organ of copulation.

Complete abdominal hysterectomy is technically a difficult operation which requires the skill and ability of an experienced well trained

gynecological surgeon. I believe that it is a generally recognized fact that gynecological surgery is a highly specialized field in medical practice, and for that reason it should be undertaken only by those who are thoroughly familiar with all phases of gynecology. An accurate diagnosis of the condition of the patient, and the resulting selection of the method to be employed at operation, are wholly dependent upon the surgeon's knowledge and experience in gynecology, unless he possesses these requisites, he should never attempt this type of operation. Most of our hospitals are now equipped with adequate facilities, but unless the surgeon has been properly trained, this equipment is of no advantage to the patient.

Because gynecological surgery is a specialized field, thorough and special training is warranted for the individual who plans to do this type of work. There are thousands of potential surgeons training in hospitals throughout the United States today whose ingenuity and capabilities are not being fully and properly utilized. This is due partly to the prevailing practice of limiting the duties and responsibilities of assistants and residents to such an extent that they have little or no opportunity to obtain any actual experience in complex surgery. Unless we train these assistants and residents in our hospitals to do what is best and necessary in surgery, our responsibility has not been fulfilled.

As previously stated, an experienced gynecological surgeon should encounter no unusual difficulties in doing an abdominal complete hysterectomy.

#### PREPARATION OF THE PATIENT

Where examination of the patient has disclosed that the pelvic condition is obscure, a urological survey should be done and an x-ray study made of the large bowel before admission to the hospital. The patient should be admitted to the hospital at least forty-eight hours before the operation. Upon her admission, she should be given sedatives to induce rest, and a low residue diet to maintain normal metabolic processes. Blood counts, urinary functional tests, and a survey of circulatory function should be routine, and any other more complex studies should be made as necessary.

A few hours before operation a small enema should be given to facilitate emptying of the colon. No effort should be made to empty the intestines with a lavative, since this would have a tendency to cause bowel dysfunction following operation.

Immediately before the operation a sedative should be given the type depending somewhat upon the anesthetic to be used. I prefer fractional spinal anesthesia, whenever it can be used. It is usually administered in small, effectual doses at intervals which can be determined during the course of the operation. This type of anesthetic gives good and adequate relaxation, prevents dangerous depression of

the blood pressure, and allows for careful and deliberate surgical technique

Immediately before operation the patient is placed on the operating table and the vagina is cleansed by scrubbing, as in many gynecological procedures. This scrubbing is followed by the use of some antiseptic, preferably a 1:1000 aqueous solution of zephiran. This is followed by any necessary vaginal plastic procedure.

A self-retaining catheter is placed in the bladder, which is allowed to remain there for seventy-two hours following the operation. This allows for continuous drainage of the bladder and was done originally because it was thought that injuries to the bladder and the ureters could be recognized early if they occurred. Fear of injuring the bladder and ureters has proved an unnecessary indication for the use of the continuously-draining catheter, but we have continued to use it because we think it decreases the necessity for nursing care. The catheter also avoids immediate postoperative bladder dysfunction and immediate postoperative morbidity due to it.

#### TECHNIC

After preparation of the vagina, the patient is arranged upon the operating table in a 15 degree Trendelenburg position, and the abdomen is opened by a right paramesial incision. Where possible, a self-retaining retractor is used to facilitate exposure of the abdominal contents. Ordinarily, the use of abdominal packs is avoided but they are sometimes necessary. The uterus and its adnexa are completely freed from other structures in the pelvis and abdomen by sharp dissection and taxis before beginning the removal of the uterus. To facilitate manipulation of the uterus, some implement for traction must be utilized. Either clamps on the sides of the uterus or a tenaculum forceps may be used. A tenaculum forceps has some advantage because it can be held farther away from the field of operation.

Ligatures are placed on the round ligaments 2 cm. from the uterus, clamps are placed on the round ligaments proximal to the uterus, and each round ligament is separated from the uterus between the ligature and the clamp. The bladder peritoneum is then incised from the right to the left side, using the incised round ligament on the right side as the beginning of the bladder peritoneum dissection. The ovarian ligaments, or the infundibulopelvic ligaments, are then ligated, depending upon whether the uterine adnexa are to be conserved or not. After placement of these ligatures, clamps are fixed on the broad ligaments to control all reflux bleeding from the uterus. The broad ligaments are then dissected on either side between ligature and clamp and the uterine vessels are exposed by careful dissection of the broad ligament near the position of the internal os of the cervix. A ligature is placed on the uterine vessels on either side. Special care is exercised to place this ligature in the parametrium and not in the myometrium.



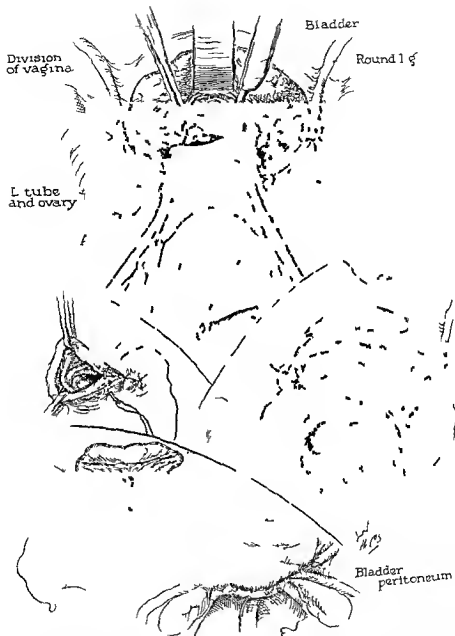


Fig 466 A Ligation of the uterine vessels separation of parametrium and division of vagina B suture closure of vagina C placement of pulley suture on left side D fixation of parametrium round ligaments adnexal pedicles and uterine sacral ligaments to closed vaginal vault E raw area peritonealized

After ligating the uterine vessels a clamp is placed above the ligation to control reflux bleeding from the uterus and the uterine vessels.

vessels are then cut directly across perpendicular to the axis of the vessels. Then the parametrium is separated from the side of the uterus, mesial to the ligature. Usually about 1.5 cm. of the uterine vessel is exposed by dissecting the parametrium before any bleeding occurs. As dissection of the uterine vessels continues, a second, and sometimes a third ligature will be necessary to control all bleeding from them. Actually the parametrium containing the uterine vessels is dissected from the side of the uterus as far as is necessary. The fascia which lies over the cervix is separated from the cervix by dissection and the fascia and bladder are then pushed from the cervix and upper vagina as far as is necessary. With this procedure, the ureters drop well out of the way and there need be no fear for their injury. After the uterine vessels on both sides have been separated, traction on the uterus will expose the uterosacral ligaments, these are ligated and separated from the uterus.

After ligating all the vessels to the uterus, and the separation of all the fascia from the cervix and upper vagina traction on the uterus will expose the upper vagina so that the cervix can be palpated through the vagina. If dissection is adequate the uterus is separated from the vagina with a knife. The incision must be made by cutting perpendicular to the axis of the vagina, or unusually free bleeding will develop in the incised vagina and parametrium. The idea in separating the uterus from the vagina as described is to avoid cutting through blood vessels which have not been previously ligated.

After removal of the uterus all vessels are religated and the vaginal canal is closed with a continuous suture of fine catgut placed very lightly and in such a way that the vaginal mucosa is inverted into the vaginal canal so that all raw edges of the vagina are approximated. It is my impression that proper closure of the vagina is one of the important details of the operation as I do it.

The round ligaments, the utero ovarian or the infundibulopelvic ligaments and the uterosacral ligaments are attached to the vault of the vagina by pulley sutures (right and left) which are fixed in the anterior and posterior vaginal walls and the paravaginal fascia. These sutures approximate all of these structures support the vagina and help somewhat to cover the exposed pelvic surface. All of the deperitonealized surfaces in the pelvis are covered with peritoneum and only one knot is exposed in the peritoneal cavity.

I prefer to use No. 0 chromic catgut for all ligatures throughout the operation and smaller catgut for peritonization of raw surfaces. Small needles have an advantage when placing ligatures and the use of clamps is meticulously avoided on structures which are not to be removed. The vaginal cuff is usually exposed and manipulated by the use of Allis forceps and placed so that no remaining tissue is injured by crushing with clamps.

The abdomen is closed by approximating the peritoneum with No.

00 chromic catgut, and the fascia is closed in a routine manner. The time, trauma and immediate blood loss during the operation are no greater than for any other type of abdominal operation. The immediate reaction of the patient to the operation is surprisingly slight and would seem to be no greater than occurs with any other major gynecological procedure.

Under spinal anesthesia there seems to be a frequently marked depression of blood pressure at the time when the parametrial structures are being isolated and ligated. This reaction when observed is controlled by the use of intravenous fluids, and without any obviously bad results to the patient.

This technic has been outlined somewhat in detail. Each gynecologist will no doubt have his own concept as to how an abdominal complete hysterectomy should be done. The important steps in the operation as I do it are, first, the avoidance of the use of clamps on structures which are not to be removed, second, the separation of the uterine vessels from the side of the uterus, third, the meticulous closure of the vagina, and fourth, the fixation of the parametrium and other structures to the vaginal vault, and finally, the use of fine catgut throughout the operation.

## NONMALIGNANT DISEASES OF THE CERVIX

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### INFLAMMATORY DISEASES

CERVICITIS is an acute or chronic inflammation of the endocervix, the portio vaginalis and deep cervical tissue. Usually all three regions are involved.

**Acute Cervicitis—Etiology**—Any pathogenic bacteria can infect the cervix. The most common offenders are the normal inhabitants of the vaginal canal where, as a rule, a wide variety of streptococci may be cultured. Gonococci are not infrequently the cause of cervicitis although this is noted more commonly in clinic practice.

Bacteria usually gain a foothold by trauma. The nulliparous young patient today generally starts her infection by using various tampons to absorb menstrual flow. This traumatic agent has given rise to more cervical infection in young women than any other means of injury.

The most common cause of cervicitis in parous individuals is labor and delivery. In the most normal parturitions mucous membranes are damaged by dilatation and further injured as the passenger moves through the cervical canal. Operative obstetrics may also contribute to cervical injury and hence to infection. Thus through childbirth the cervix may be injured and subsequently infected or be infected as an integral part in the over-all picture of puerperal sepsis of varying degrees. Lacerations lead to chronicity in the infections by carrying the organisms into deep tissue.

Gonorrhea is a third cause of cervicitis, being introduced almost always by coitus.

**Clinical Picture**—In the acute stage the cervix appears red and edematous with a profuse mucopurulent discharge issuing from the canal. A smear will show offending organisms, leukocytes, epithelial cells and mucus. Patients with acute cervicitis complain of leukorrhea and if gonorrhea is the cause they also note vulvovaginal and urethral irritation.

**Diagnosis**—One must make a careful, orderly pelvic examination. In the cases of gonorrhea involvement of the periurethral and/or vulvovaginal glands will usually be manifest. With these findings one should inspect and examine the cervix carefully so as not to carry infection to it if it is not already there. Cultures should be taken

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routinely since they are far more reliable than smears for diagnosis of gonorrhea.

**Treatment**—Chemotherapy gives the best result in gonorrhea. Sulfadiazine, 4 gm a day for forty eight hours followed by 2 gm daily for an additional ten days, is the drug of choice. Penicillin, 100 000 Oxford units every twenty four hours for two days although not as convenient to administer, seems to be reliable. Oral penicillin may prove to be equally efficacious although the necessary dosage has not been worked out as yet.

Local treatment in acute gonorrhea is as a rule contraindicated. Results from chemotherapy are rapid, thus discomfort is short lived. Douches may force the infection into the uterine canal leading to subsequent infection of the internal genitalia and for this reason are not advised. In cases in which the discharge is profuse causing maceration of tissue one may introduce vaginally either Ceepryn suppositories 1 1000 or zephiran chloride solution in a water soluble base. Naturally the general hygiene rules for gonorrhea must be enforced during the active treatment stage.

Acute cervicitis of nongonorrheal origin is best treated by local therapy. The vagina, portio vaginalis and endocervical canal should be scrubbed with Ceepryn Chloride 1 1000 (cetylpyridinium chloride) as the initial therapeutic step. Next the patient is directed to insert a Ceepryn suppository (1 1000) every night at bedtime for ten days.

**Chronic Cervicitis**—In a very high percentage of cases of acute cervicitis the disease progresses to a chronic state causing leukorrhea the most frequent of all gynecologic complaints.

**Etiology**—Although it is often difficult to prove (even by culture) gonorrhea may be the cause of this lesion. More commonly chronic cervicitis follows injuries from delivery or the continued use of tampons for absorption of the menstrual flow. Instrumentation or the stem pessary is an uncommon cause. Whatever the modus operandi may be one of the streptococcus or staphylococcus groups will usually be the bacterial agent. There seems to be little doubt that an alteration in the vaginal pH from its normal 4.5 favors growth of pathogenic bacteria. Maintenance of this hydrogen ion concentration is apparently not disturbed in a healthy woman. She may, however, disturb it and promote pathogenic bacterial growth by using any number of widely advertised douches or homespun solutions for feminine hygiene. An unhealthy vagina can thus be created allowing the cervix to be constantly attacked and finally deeply infected.

**Clinical Picture**—A wide variety of chronic lesions may be seen. The most difficult of all to demonstrate is the endocervical or canal infection for the portio vaginalis or vaginal portion of the cervix appears normal. On inspection the canal when dilated is granular and often soft. A thick tenacious mucopurulent plug is seen coming from the canal. This material is difficult to dislodge.

Another common chronic lesion is the so called *erosion* (Figs 467 and 468) The normal epithelial covering is gone in such instances and we see a red granular appearing portio of varying size Many doctors like to call such lesions 'ulcers' when explaining the condition to patients Actually it is more like a 'brush burn' with an over



Fig 467.—Erosion of the cervix. (From Curtis Textbook of Gynecology )

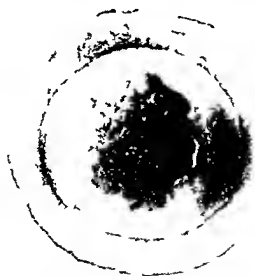


Fig 468—Erosion of the cervix An erosion such as this is faintly suggestive of malignancy, but the friability and bleeding of cancer are wanting (From Curtis Textbook of Gynecology )

lying clot Retention or Nabothian cysts may form following the plugging of the cervical glands by surrounding cervical infection Thus erosion may be seen with or without these small collections of clear mucus Deep seated infection in the glands will change the clear mucus to thick purulent material

*Ectropion* or *eversion* (Fig. 469) is another chronic cervical lesion caused by deep lacerations. In such cases the external os is patulous and opens like a 'fish mouth' when viewed with the usual speculum. The endocervical canal, as well as part of the portio vaginalis is red and granular. The entire cervix is hypertrophic and edematous.

It is highly important to remember that any reddened area about the cervix may be carcinoma. We often see early cancer as a part of *erosion* or a single area looking like *erosion*. There is nothing to distinguish grossly a benign or malignant lesion. Both bleed when traumatized, the cancer more freely. Any area of chronic cervicitis that bleeds must be biopsied if carcinoma is to be diagnosed early. It is regrettable that many cervical cancers are treated locally for what the physician thinks is chronic cervicitis. We strongly urge the free

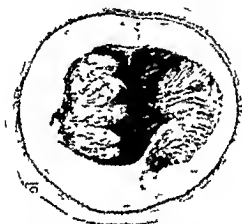


Fig. 469. A lacerated and everted cervix. Confusion with *erosion* is common. (From Curtis: Textbook of Gynecology.)

use of biopsy in the office. Only in this manner can a correct diagnosis be made.

Although the aforementioned lesions are usually encountered in women who have borne children or at least have a dilated hymen, *erosion* may occur in very young virgins soon after the menarche. Their complaint is leucorrhea and examination under anesthesia reveals a *congenital erosion*. What the cause of this condition is remains obscure although the pH of the vagina is most likely a factor.

**Treatment**—All chronic cervical lesions should be promptly and adequately treated. Whether they play any part in the development of cervical carcinoma cannot be positively stated. However the clear resemblance of early carcinoma to *erosion* or the appearance of carcinoma in an *erosion* makes me unhesitatingly advise the treatment and irradiation of all lesions. Formerly the use of silver nitrate, other caustics, medicated tampons and the like kept the patient under treat-

ment a long time but did not "clean up" the cervix as well as other methods

A common effective method that gives quick results and is an office procedure is electrocauterization. Various sized cautery tips are at hand for the average case. After the vagina and cervix are cleaned out the portio vaginalis is stroked with the heated cautery point in a radial fashion from the external os outward. The treatment requires no anesthesia. For about two weeks following cauterization the patient will have a heavy mucoid discharge, occasionally tinged with blood. White vinegar douches (2 ounces to 2 quarts of water) will help clear the discharge and promote epithelialization. In some cases the treatment may have to be repeated in six to eight weeks. If the cervix does not heal promptly and a biopsy has not been taken cancer should be suspected. If one is treating erosion with ectropion the cautery

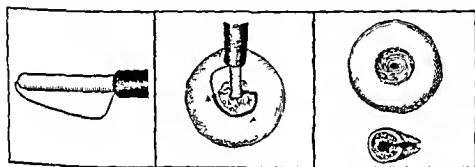


Fig 470

Fig 471

Fig 472

Fig 470—The new electrode for wider conization

Fig 471.—Indicating the method of using the electrode i.e. a wide excision taking in all of the affected area

Fig 472—The excised cone of tissue also the remaining funnel shaped cavity which heals rapidly with good inversion (R. J. Crossen, J. Missouri M. A. From Crossen, H. S. and Crossen, R. J. *Operative Gynecology* 5th ed. C. V. Mosby Co.)

tip may be carried inside the external os where there is little danger of creating a cervical stenosis. In place of actual cautery one might use a diathermy machine with proper attachments for not only coagulating the lesion but taking biopsies with a cutting loop.

The massive cervical lesions—be they lacerations, erosions, cysts or edema—will require more than cauterization or diathermy. I prefer to treat almost all of these by conization using the technic of Hyams (Figs 470, 471 and 472). It is indeed surprising to see the uniformly good results obtained with the high frequency electrode (Hyams' knife). Although this minor operation may be done in the office we prefer hospitalization since intractable bleeding might occur. Although we have never seen such an accident, it could happen and an office is a poor place to treat a cervical hemorrhage.

Deep seated infection and massive multiple lesions may make trach



eloplasty necessary, in which case the Sturmdorf amputation may be done. It is noteworthy, however, that conization is increasing in popularity and tracheloplasty is fast being abandoned in many clinics throughout the country.

#### TUBERCULOSIS OF THE CERVIX

Tuberculosis is an uncommon lesion of the cervix. Although it may be primary in the pelvis, all cases seen by me have been associated with tuberculosis of the upper genital tract.

The lesion is extremely important since it is usually diagnosed grossly as carcinoma. One patient we have seen received a full course of radium for carcinoma of the cervix before the pathologic report revealed the true diagnosis. Thus, one must caution against treating any lesion and particularly those of the cervix until the proper diagnosis is made.

Clinically tuberculosis of the cervix appears the same as an advanced malignant tumor of the proliferative type. Although the granuloma will bleed on the manipulation of examination, patients generally give no history of postcoital spotting. They complain of leukorrhea and pain from upper genital disease.

The diagnosis is made by curettage of the uterine canal and biopsy of the cervix. Frequently at this time one finds evidence of adnexal as well as uterine disease.

The treatment is panhysterectomy and removal of adnexal lesions if they are present. Naturally, such radical surgery is only done when there is no evidence of advanced systemic disease.

#### CERVICAL POLYP

Small pedunculated tumors may spring from the cervical canal or less commonly the portio vaginalis. These fleshy, fragile red neoplasms are called polyps and may vary considerably in size from a few millimeters to many centimeters.

**Symptoms**—Cervical polyps are often found on routine examination, having given rise to no symptoms. Usually polyps cause postcoital spotting or intermenstrual bleeding, thus simulating the first symptoms of carcinoma of the cervix. Polyps in pregnant women are often the cause of bleeding which is mistakenly treated as threatened abortion.

**Treatment**—Polyps should be removed. If small they may simply be excised by cutting the pedicle and cauterizing the base. A tonsil snare offers an excellent medium for getting the base of a pedicle up in the cervical canal.

All polyps should be examined histologically. We have seen three that were malignant. In cases of intermenstrual bleeding where a polyp has been found, it is not wise to assume one has the whole answer. Curettage should be done at the same time as polypectomy in order to completely rule out uterine malignancy.

## MYOMA OF THE CERVIX

Although this subject belongs with a general discussion of myoma of the uterus, it may present a picture of cervical tumor only.

These tumors if large will very often displace the bladder markedly and may even obstruct the urethra by pressure. Pedunculated cervical myomas may be removed from below much like a polyp. The large ones require panhysterectomy, or if they occur in a cervical stump, removal of the entire cervix.

## CERVICAL LACERATIONS

Cervical lacerations are usually due to childbirth. They may occur in what appears to be the most normal parturition, but as a rule operative interference is the cause. The energetic use of pituitary extracts to hasten delivery, manual dilatation of the cervix, forceps delivery—all contribute to damaging the cervix. The surgeon may lacerate the cervix in dilating as a preliminary to curettage.

Tears may occur anywhere in the cervix. They may be single or multiple, limited to the cervix or they may travel out into the base of the broad ligament.

Since lacerations and infection go hand in hand they were discussed under the heading of chronic cervicitis. There remains, however, the tear that has occurred with delivery and extended into the parametrial tissue. Upon healing, a painful contracture develops. The discomfort is mainly noted during coitus. Treatment is none too satisfactory, however, short wave diathermy will loosen the scar tissue, increase cervical mobility and as a rule decrease pain. Complete erasure of the infection and lacerations in the cervix per se will have a beneficial effect upon the extended tear into the broad ligament.

## INDICATIONS AND CONTRAINDICATIONS IN THE IRRADIATION THERAPY OF BENIGN UTERINE CONDITIONS

GEORGE A. HAIN, MD \*

IRRADIATION therapy (radium and x ray) is one of the essentials of gynecology which is employed almost as frequently as surgery. When used properly with recognition of definite indications and contra indications certain benign uterine conditions may be treated efficaciously by irradiation with a minimum of discomfort and loss of time to the patient.

It must be emphasized that radium and x ray are dangerous physical agents which, if incorrectly used, may produce irreparable damage. No one should attempt to use irradiation therapy without at least a fundamental knowledge of the physics of radiation.

Before any patient is selected as a candidate for x ray or radium therapy, the same careful studies must be carried out that would ordinarily precede a major surgical procedure. A careful history with especial attention to the possibilities of pregnancy or its complications (retained gestational products) must be taken. A thorough physical examination should be done. This should include a rectal examination and, of course, a bimanual pelvic examination. The cervix should be completely visualized through a well lighted speculum.

The usual laboratory studies are made, including a blood count and urinalysis. When these studies have been completed a decision as to the advisability of irradiation therapy may be made.

In contrasting irradiation with surgery, there are differences which are at once apparent. Economically, irradiation is much more desirable. The patient who is receiving external irradiation does not have to stay in the hospital at all while the patient who is being treated with local radium is ordinarily sent home after about a week's stay. The average patient who has been treated surgically for a major uterine condition is usually hospitalized for fourteen to sixteen days and then does not return to full activity for six or eight weeks. The expenses of an intrauterine radium application or fractional x ray treatments are much less than those of a longer hospital stay with its attendant anæsthesia, operating room and professional fees.

There are individuals in whom operative management is contra indicated because they are poor surgical risks. Included in this group

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would be the aged patient with a poor life expectancy, the obese woman in whom operation would be difficult and dangerous, and those individuals with systemic diseases such as diabetes, cardiovascular disease, blood dyscrasias and the like. It may be psychologically hazardous to operate upon certain patients. Ordinarily, however, one should not be persuaded by the referring physician or the patient (because of fear of operation) to treat a case radiologically if the case were better treated surgically.

On the other hand, the patient may be encountered who is mentally a very poor subject for irradiation. Such a patient may have heard tales to the effect that radium always produces frightful burns, that x-ray causes insanity or that x-ray makes one grow old fast. If careful explanation of the true facts proves fruitless, it may be judicious to employ surgery even though all indications would be toward irradiation as the treatment of choice.

Pregnancy is an absolute contraindication to irradiation because of the danger of injury to the fetus and the possibility of inducing an abortion except when cervical carcinoma is a complicating factor. In the patient with a symmetrically enlarged globular uterus even with a history of fairly regular cyclic bleeding, it is important to obtain a biologic test for pregnancy before diagnostic curettage is performed and before any form of irradiation therapy is instituted.

The largest group of patients have *excessive vaginal bleeding* as a common symptom. This may be caused by fibromyoma uteri, fibrosis uteri (metropathia haemorrhagica) or may be due to bleeding without demonstrable pathology (so called functional bleeding).

Every patient with excessive or irregular vaginal bleeding as a symptom must be considered a candidate for malignancy, either fundal or cervical. It is unfortunate that pain is another infrequent symptom in association with vaginal bleeding, since women will demand treatment for painful conditions but will delay seeking advice in respect to vaginal bleeding. Until the presence or absence of carcinoma is proved, no vaginal bleeding may be assumed to be benign in origin. This factor becomes increasingly important with the older age group. In order to rule out malignancy, it is imperative that a diagnostic curettage be done prior to or at the time that irradiation therapy is instituted. A thorough curettage must be performed since small areas of carcinoma may be missed if a superficial or suction curettement is relied upon. It is our custom to curet the cervical canal carefully in all instances and if the cervix is at all suspicious in appearance a biopsy is taken from this region. The study of the vaginal smear, stained by the Papanicolaou method, is being used more frequently and is proving to be a valuable aid in the diagnosis of malignancy of the female genital tract by calling attention to the possibility of its presence, which must then be proved by biopsy or curettage.

The term *functional bleeding* refers to that type of excessive uter-

ine bleeding for which no apparent systemic or local cause may be found. This may occur in any age group, and is thought to be due to endocrine disturbances. In the younger patient (adolescent and early reproductive period), all examinations and studies (including basal metabolism, and oftentimes blood and urine hormone determinations) should be done. If hormonal therapy does not prove effective and the vaginal bleeding continues, in the *rare* case it may be necessary to institute radiological treatment. In the Jefferson Clinic, we prefer to use radium. It is wise to use less than 600 mg-hours of radium so that the danger of permanent castration will be minimized. In the older age group (premenopausal or menopausal) when malignancy has been ruled out by curettage, it is advisable to use a greater dose of radium so that a permanent cessation of the menses will occur. In our cases, we employ one (or two in tandem formation, depending on the depth of the uterine cavity) radium capsule(s). The filtration is 1.5 mm of platinum and 1.0 mm of black or pararubber tubing. The radium is usually allowed to remain so that a total dosage of 1800 to 2400 mg-hours is received by the patient.

*Fibrosis uteri* (metropathia haemorrhagica) is common in the fourth and fifth decades of life. Patients with this condition usually menstruate excessively and occasionally have associated intermenstrual bleeding. The average patient in whom this diagnosis is made has had fairly numerous pregnancies, either full term or otherwise. On examination, the uterus is found to be uniformly enlarged, oftentimes boggy, heavy and sometimes retroverted. The degree of enlargement is usually not excessive. Here, the treatment consists of diagnostic curettage, and if no submucous myoma is discovered, an intrauterine radium application is given. We usually administer 1200 to 2400 mg-hours of radium depending on the age of the patient and the depth of the uterus. At the same time, any necessary vaginal plastic procedure is carried out.

In the Jefferson Clinic, whenever radium is used to treat vaginal bleeding due to a supposedly benign uterine condition, a rapid (four or twenty-four hour) pathological report is requested on the material removed by curettage so that if unsuspected malignancy is discovered a greater dose of irradiation may be administered preliminary to surgical extirpation at a later date, as in the case of fundal carcinoma. External irradiation is usually not employed in treating functional bleeding or fibrosis uteri (metropathia haemorrhagica) in our clinic.

*Fibromyoma uteri* may be treated quite successfully by means of irradiation. With this type of tumor a nicety of judgment is necessary, in order that the treatment given may be the one that is best suited to the welfare and comfort of the individual patient.

The age of the patient must be given careful consideration. Uterine fibromyoma may be influenced by small doses of irradiation, but it is

almost always necessary to produce irradiation castration in order to achieve the best results of treatment. Obviously, in the woman under forty, this is undesirable. Myomectomy may be possible, and if so a functioning uterus can be preserved. If hysterectomy is deemed necessary, ovarian function may be conserved so that menopausal symptoms may be postponed or lessened. Young patients with fibromyoma uteri should not receive irradiation therapy unless absolute contraindications exist for surgical management.

It may be impossible to make a definite diagnosis in certain patients because of difficulty in performing satisfactory examination. This may be true in extremely obese patients and in the occasional patient when an ovarian enlargement simulates a uterine irregularity or enlargement.

If in doubt, exploration should be done so that an accurate diagnosis is made—even if irradiation therapy is eventually used.

The patient may have fibromyoma uteri which could be properly treated by irradiation, but because of associated cysts or neoplasms it may be wiser to treat the entire pelvic condition surgically. Fibromyoma uteri should never be regarded as the sole cause of vaginal bleeding until an accompanying adenocarcinoma of the endometrium has been ruled out. Twenty-five to 35 per cent of fundal carcinomas have fibroids associated with them.

Pelvic pain when caused by pressure may be a contraindication to irradiation. If the pain is slight and the tumor is small, a trial of irradiation may be given. If the treatment is unsuccessful, surgery will have to be utilized later on. If the pain is severe, it is best to treat the condition surgically, without any trial of irradiation.

Caution must be used in using radium in the deeply retroverted and fixed uterus. Adequate drainage may not be possible, and the chances of a subsequent pyometra will have to be borne in mind.

Fibroid tumors with calcification, as detected by x-ray, do not respond well to irradiation, and if pressure symptoms are present, they should be removed surgically.

The *freely-movable, pedunculated, subserous myoma* should always be removed by operation, for at any time torsion may occur and precipitate an acute abdominal condition. Pedunculated submucous fibroids are not suitable for irradiation unless there is an exceptionally broad sessile base present, since serious infection may result. This is the type of tumor that is frequently not diagnosed until curettage is performed, and the curet detects the irregularity in the uterine cavity. Occasionally the site of implantation is low and the submucous tumor may be removed vaginally. If this type of tumor is irradiated one may expect a persistent foul-smelling vaginal discharge to result, due to ulceration and infection, as noted. When this takes place, operative removal is necessitated, after the subsidence of the acute infection.

Surgery is advisable when *degeneration of the myoma* is suspected.

This may be evident by softening and tenderness of the tumor. Another clue is an elevated sedimentation rate in the absence of fever, leucocytosis, pelvic inflammatory disease or coexistent infection. Whenever the history indicates that a uterine tumor has increased rapidly in size, surgery is preferred, since the rapid growth may be due to sarcomatous transformation within the tumor. The best results are obtained in this condition by radical surgery followed by irradiation, or if suspected primarily by preliminary irradiation therapy.

*Coincidental pelvic inflammatory disease* is quite commonly associated with myomata uteri. If the infection is not acute there is no contraindication to treating the tumor radiologically after a reasonable period of observation. However, an acute or subacute salpingitis may sometimes be exacerbated by a diagnostic curettage or even by a pelvic examination. By the same reasoning, an intrauterine application of radium should not be given. If the need is great to treat the myoma complicated by associated inflammatory disease, external irradiation would be the safer course. The inflammatory condition often is unchanged by the treatment given.

Most gynecologists hesitate to irradiate tumors that are *larger than a three to four months pregnancy*. However, if an adequate radium application can be made so that the entire length of the uterine cavity is properly irradiated, large tumors may be treated successfully. Too often, however, tortuosity of the canal makes the application difficult so that a satisfactory treatment cannot be given. In large tumors where surgery is contraindicated, a combination of radium and x-ray may prove more effective.

Corscaden<sup>1</sup> studied over one hundred cases with tumors larger than a three months pregnancy, over a period of years. Intrauterine radium was used, sometimes with the addition of deep x-ray therapy. In 63.4 per cent of his cases the tumor completely disappeared, there was considerable shrinkage in 29.5 per cent of his cases, and in only 7 per cent was there no appreciable change in the size of the tumor. Surgery is usually employed in our clinic for the larger tumors.

In properly selected cases, irradiation has certain advantages over surgery in the treatment of uterine myomas. According to Pohle, fibroid surgery has a mortality of upwards of 1 per cent with experienced operators, and with the occasional operator this figure is higher. Intrauterine radium has a very small mortality (a fraction of 1 per cent), and external irradiation has practically no mortality.

Complications are rather unusual following irradiation, whereas there is usually some incidence of postoperative complications (phlebitis, wound infections, and so on), following fibroid surgery.

According to Ernst<sup>2</sup>, severe postmenopausal disturbances due to irradiation occur in less than 1 per cent of patients who have been treated for myomas. Our impression is that the incidence of such disturbance is somewhat greater.

The results of irradiation for myoma are excellent. Ernst obtained 50 to 100 per cent reduction of the tumor in 97 per cent of his cases (500) and in the remaining 3 per cent although the shrinkage was not as great the symptoms were completely relieved. Other authors report similar results.

Mention should be made of the use of irradiation in *pelvic tuberculosis* where the endometrium is involved. McIntosh<sup>4</sup> recommends that when disease of the endometrium alone is diagnosed by biopsy or curettage and no symptoms are referable to the tubes or peritoneum that x ray should be used first as a primary procedure including the tubes in the treated field. Surgery is preferred as a primary procedure in our clinic unless extensive adhesions prevent adequate and complete surgery and then external irradiation is employed as an alternative.

Reidenberg<sup>5</sup> reports good results by using low dosage irradiation to the pituitary gland and ovaries in patients with amenorrhea and *dysfunctional uterine bleeding*. He concluded from his long term survey that the irradiation as given according to the technique of Eidel<sup>6</sup> had no deleterious effect upon the generative organs or upon the offspring of the first generation. It is not our custom to employ this type of therapy in the Jefferson Clinic.

Kaplan<sup>7</sup> reported good results in *pubertal bleeding* by treating the spleen and pituitary. We have had no experience with this type of therapy.

#### SUMMARY

- 1 Irradiation (x ray and radium) is a valuable but sometimes a dangerous therapeutic agent.
- 2 Careful examination and study is necessary prior to instituting irradiation therapy.
- 3 Irradiation is more economical and less time consuming than surgery.
- 4 Systemic disease may contraindicate surgery.
- 5 Pregnancy contraindicates irradiation therapy except as noted.
- 6 In any patient with vaginal bleeding the presence of carcinoma must first be considered. Diagnostic curettage must always be performed prior to irradiation therapy or carried out at the time of the intended radium application.
- 7 Functional bleeding and fibrosis uteri (metropathia haemorrhagica) are successfully treated by irradiation in most instances.
- 8 Indications and contraindications for treating fibromyoma uteri are discussed and the satisfactory results from treatment have been commented upon.
- 9 Mention is made of the treatment of pelvic tuberculosis and dysfunctional uterine bleeding by means of x ray.



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## BACKACHE IN WOMEN AND UTERINE RETRODISPLACEMENT

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BACKACHE is one of the most common complaints of womankind. The fact that there have been over 500 articles<sup>1</sup> written in the English literature on this subject during the past four decades is clear evidence that this symptom has caused a great deal of concern and speculation among the members of the medical profession. Even so, this symptom is often dismissed lightly or ignored entirely.

Through the centuries the presence of backache in the adult female has almost always been attributed to some disorder of the reproductive organs. This idea dominated medical thought until the early part of the present century when the specialty of orthopedics, making great progress under such leaders as Goldthwait and Lovett gave logical explanations for this symptom in many cases. The pendulum of thought then swung away from the gynecic point of view and many of the profession believed all backache to be orthopedic in origin. This brought about a controversy between two schools of thought which led to a certain degree of confusion which still exists today. We may be quite certain that the true answer lies between these two extreme points of view.

It is definitely known that backache in women may be due to orthopedic causes such as disease of the sacroiliac joints, subluxations, arthritis, postural defects, trauma, abnormal conditions of the feet and disease of the pelvic bones and vertebrae themselves, to mention but a few. We are also cognizant of the fact that neurologic diseases, urologic disorders, rectal and other gastrointestinal conditions as well as certain toxic conditions and focal infections may cause this symptom. That there are certain well defined gynecologic conditions which give rise to this complaint is unquestionably true.

This discussion will be confined to the backache met with in obstetric and gynecologic practice. In such a study all of these etiologic factors must be kept in mind and it must also be recognized that such a complaint may arise from any number of combined causes or coexistent factors.

### OBSTETRIC ASPECTS OF BACKACHE

*During Pregnancy*—Pain in the back is not infrequently experienced during pregnancy and may occur at any time during gestation al

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though it is more common during the latter months. While it may be severe this symptom is usually an annoying pain which adds to the vicissitudes of the woman growing great with child. It is often alluded to as pressure pain and more often than not nothing is done about it. Except for those cases of pyelitis of pregnancy and the lesser degrees of ureteral obstruction which give typical renal pain and tenderness and which is usually unilateral almost all back pain during pregnancy is originated in the back itself although recently a few cases of slipped intervertebral disk have been reported.<sup>3</sup> The most common etiologic factors are relaxation of the pelvic joints, faulty posture, the gradual changing of the center of gravity of the body and fatigue.

Relaxation of the pelvic joints alone rarely causes backache for this is a physiological process which commences early in pregnancy and continues until the sixth or seventh month. Hisaw<sup>4</sup> and others have shown this phenomenon to be due to the influence of a hormone present during pregnancy called relaxin. However it may readily be understood how any added force or strain could more easily have an exaggerated effect upon these joints which have become widened and more mobile because of the attenuation and increased pliability of the ligaments. Thus poor posture which is extremely common among women may have a profound effect upon these loosened joints and bring about the added strain which is followed shortly by muscle spasm and finally by pain. The sacroiliac joints are often affected because they bear much of the weight of the body and are intimately associated with the stability of the pelvis. The other common site of backache during pregnancy is in the lumbosacral region where an ever increasing change is taking place as the uterus enlarges and the center of gravity of the body is gradually shifted forward. A compensatory lordosis develops which puts added stress on the lumbosacral joints and their attachments and when accompanied by poor posture, flabby musculature or obesity (especially in multiparae) any overt action is likely to cause abnormal motion of the relaxed joint with the resultant spasm and pain. Sheer fatigue is an important factor in any kind of backache and in pregnancy it commonly initiates the vicious cycle mentioned.

**Postpartum**—Backache following pregnancy is even more common than during gestation. While there may be transient discomfort immediately following delivery, this almost always disappears shortly. The usual backache occurs one or two months following delivery and may be sacroiliac or lumbosacral and commonly is worse in the evening in the presence of fatigue. While gynecologic conditions may be at fault such as residual parametritis, extensive lacerations and relaxations or marked retrodisplacement of the uterus, it seems singularly true that these states rarely cause the typical postpartum backache.

The relaxation of the joints disappears to a great degree three or four weeks following delivery but it is quite certain that they never

completely return to normal. Almost invariably postpartum backache is secondary to a sequence of events. Besides some residual joint changes and the back strain resulting from the previous compensatory lordosis there is also abdominal relaxation. Labor may have been a severe tax on the patient's physical strength and this has been followed by a period of complete bed rest which makes for generalized muscular weakness. She then arises and goes home to new and greater responsibilities than she has ever before experienced. The care of the child means longer hours on her feet, more bending and lifting and a frequently interrupted sleep. Therefore a state of chronic fatigue is developed which leads to poor posture, muscular spasm and finally backache.

**Treatment**—It is quite evident that most obstetrical backache is orthopedic or local in nature. Too much stress cannot be laid upon the taking of a careful history as to previous injury or disease of the spine, pelvis or lower extremities. That every pregnant woman should have her back examined there can be no doubt. During the routine prenatal measurement of the pelvis, the length of the lower extremities should be compared and the arches of the feet closely inspected. In this way any condition that may possibly cause difficulty as the stress and strain of pregnancy is slowly added may be known before symptoms arise. The addition of a lift in the shoe to compensate for minor discrepancies in length of the legs or of arch supports when necessary (especially in cases of acquired flatfoot) have frequently relieved back pain. The following points are important in the treatment of both prenatal and postpartum backache.

**GENERAL PROCEDURES**—General measures include the following: (1) *Maintenance of good posture*. (2) *Avoidance of fatigue* by insisting on adequate sleep each night and rest at stated intervals during the day such as 10 A.M., 2 P.M. and 5 P.M. for thirty to sixty minutes depending upon the need. Long automobile rides or other trips of great length should be discouraged. (3) *Avoidance of strain* such as lifting heavy articles, reaching toward high places or any violent exercise. The greatest care should be taken during delivery in handling patients carefully under anesthesia. (4) *Avoidance of excessive weight gain*. While it is mandatory during pregnancy, it is especially important during the postpartum period to avoid this cause of added strain.

**SPECIFIC MEASURES**—1. *Abdominal pelvic support*. In the more severe cases in which simple measures are not sufficient, a mechanical support is of the greatest value. In the pregnant woman it protects the pelvic joints from overmotion and with this prevention of strain muscular spasm and pain are much less likely to occur. Simple strapping with adhesive tape may be sufficient but it is temporary and often irritating so that the maternity belt or corset is the device of choice (Fig. 473). This should extend over and above the lumbar region, the front and back of the belt being of firm fabric and its sides of elastic

or adjustable with laces. In the postpartum case a similar support may be used, a special type being available for sacroiliac disorders (Fig 474)

2 *Heat, massage and diathermy* are valuable adjuncts to rest and support as these relieve muscular spasm

3 *Complete bed rest* is rarely necessary but on occasion complete immobilization in bed for a few days is of great value. The placing of boards under the mattress is practiced by some with success

4 *Drugs* The usual doses of salicylates and mild sedatives are of transient value as symptomatic treatment. Occasionally the injection of a joint with 0.5 per cent novocaine gives complete relief in a stubborn case

5 *Orthopedic consultation* should be obtained in all severe cases



Fig 473—Ambro maternity corset

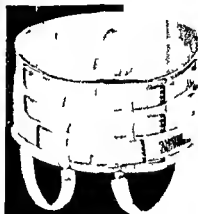


Fig 474—Ambro sacro iliac belt

#### THE GYNECOLOGICAL ASPECT OF BACKACHE

It is estimated that one out of every four patients visiting a gynecologist complains of backache.<sup>5</sup> Not all of these are due to gynecologic conditions to be sure but a significant number are. It is true that gynecologic cases almost always have other symptoms besides backache, in fact, it is quite rare for a patient with real pelvic disease to complain only of backache *per se*.

**Causes**—Gynecologic backache is characteristically a diffuse midline pain in the region of the sacrum although it occasionally is at the lumbosacral junction. It almost never goes higher than this and it is very rarely a unilateral pain. It is generally conceded<sup>6</sup> that painful stimuli from the female internal reproductive organs are connected

with the tenth thoracic to the first lumbar nerves and the second to fourth sacral nerves. The pain from these fibers is referred along the somatic nerves from the same level of the spinal cord. The somatic nerves from the above mentioned cord levels are distributed over the sacral region which gives anatomical credence to the existence of gynecologic backache. True gynecologic backache is produced either by infiltration, traction, congestion or direct pressure.<sup>8</sup>

*Infiltration* or induration of the pelvic structures is a common cause of backache. This includes inflammations, especially those involving the uterosacral ligaments which is often secondary to chronic endocervicitis. It also includes malignancies of the cervix fundus or adnexae and endometriosis which frequently causes great induration in the cul-de sac of Douglas and the uterosacral ligaments.

*Traction* with subsequent pain in the back may be caused by large tumors when associated with adhesions. It is characteristically true however, that large symmetrical tumors which ride above the pelvic brim rarely cause backache unless adhesions are present and traction upon them takes place. Heavy hydrosalpinx or hydrosalpinx hanging down into the cul de sac exerts an abnormal pull on the broad ligaments. Vaginal relaxations, cystocele and rectocele caused back pain in 75 per cent of one series of cases.<sup>9</sup> Partial prolapse of the uterus is a common cause of backache produced by traction but this symptom is seldom seen in cases with complete procidentia probably because the ligaments and fasciae are attenuated to such a degree that no real tension is present at that stage. Complete retrodisplacement of the uterus and prolapsus of both adnexae into the posterior cul de sac occasionally produces enough traction to cause backache. A pendulous abdomen with a strained forward position of the intra abdominal organs causes backache at times.

*Congestion* was thought by the older writers to be the most common cause of backache in women. Truly it is seen most commonly during menstruation or the premenstrual period. Congestion is present in pelvic inflammatory disease, especially in the acute stage, as well as in some pelvic tumors and in some cases of complete retroversion of the uterus with dependent passive hyperemia. There is undoubtedly congestion in many cases of prolapse of the uterus and vaginal relaxations, but in many of these cases there is no such symptom. It may be safely assumed that congestion is at least a contributing cause to backache in women.

*Pressure* caused by tumors, cysts, inflammatory masses and retroversions of the uterus may cause back pain.

*Differential Diagnosis*—Since it is evident that many backaches in women are not gynecological in origin whether or not they be associated with pelvic disease, it is wise to use all the possible methods of differential diagnosis in evaluating the cause of this symptom. The outline proposed by Crossen<sup>10</sup> has proved very satisfactory.

## HISTORY

- 1 *Origin* Was the onset of the backache connected with childbirth pelvic infection abortion operation or was it initiated after trauma or a toxic illness?
- 2 *Associated Symptoms* Has there been any other symptom of genital disease, such as pain in the lower abdomen vaginal bleeding or discharge or bearing down sensation?
- 3 *Progress* Has the backache been continuous or intermittent? Has it increased in severity? Is it associated with the menstrual cycle?
- 4 *Effect of Previous Treatment* Has the backache improved at any time under gynecologic treatment? If not what measures have seemed to give relief?

## EXAMINATION

## 1 LOCALIZATION OF THE BACKACHE

- a *Sacral Region* If it is a diffuse aching extending all the way across the back without any definite tender spots a gynecologic lesion must be strongly considered. If there is definite tenderness upon palpation of either sacroiliac region or if there is aggravation of the pain in this area by movement there can be little doubt that the sacroiliac joint is at fault.
- b *Coccygeal Region* Commonly complained of and rarely due to intra-pelvic disease. Rectal examination reveals tenderness in the region of the sacrococcygeal joint.
- c *Lumbosacral Joint* This is apt to be due to some orthopedic cause.
- d *Midlumbar Region* Usually due to arthritis or muscular spasm secondary to an orthopedic difficulty.
- e *Upper Lumbar Region* If central it is usually due to spinal disease; if lateral it may be renal or due to muscular spasm.

## 2 INTRAPELVIC EXAMINATION

- a *Inspection of the vulva and vestibule* for signs of inflammation such as redness, tenderness, swelling and involvement of the urethra, Skene's or Bartholin glands. The vaginal introitus is carefully inspected for lacerations or relaxation.
- b *Palpation and testing the integrity of the anterior and posterior vaginal walls* this is especially well aided by having the patient strain as if at stool in order to reveal the presence of cystocele, rectocele or prolapse of the uterus.
- c *Visualization of the cervix* is then accomplished with the aid of a bivalve speculum and the presence of any lesion such as erosion, laceration, new growth or infection is searched for.
- d *The bimanual pelvic examination* is then made. The posterior cul-de-sac is palpated and then the fornices on either side and above the cervix are felt for the presence of masses or tenderness. An attempt is made to palpate the uterosacral ligaments behind the cervix especially in cases of endocervicitis to ascertain whether or not they are indurated or tender. The fingers are then pushed up high behind the uterus until they touch the promontory of the sacrum to see if that portion of the spine is tender. The size, mobility, position and contour of the uterus is then determined by palpating that organ between the internal and external fingers. With the vaginal fingers in one of the lateral fornices, the abdominal hand is swept off of the uterine cornu on the same side in search of the adnexa; this is then repeated on the other side.
- e *The rectal examination* is extremely important and is too often neglected. The lower portions of the broad ligaments and the uterosacral ligaments can often be felt better this way. This examination is especially

valuable in cases of carcinoma of the cervix and endometriosis and should never be omitted. The coccyx and sacrum can easily be palpated for tender points by the rectal finger.

- f The combined *rectovaginal examination* with the forefinger in the vagina and the middle finger in the rectum is the best maneuver for determining the presence of nodules in the rectovaginal septum.

If a pelvic lesion is found there comes the question as to whether or not it is a factor in the backache. It must be kept in mind that the coexistence of a pelvic lesion and backache are not necessarily cause and effect. In this connection there are three questions to be answered:

- 1 Is the pelvic lesion one that is likely to give rise to backache?
- 2 Is the backache the type that is likely to be caused by the pelvic lesion?
- 3 Is there any other probable cause for the backache?

Carefully considered answers to these questions will aid a great deal in determining whether or not the backache is of intrapelvic origin.

**Treatment**—The patient with a gynecologic disease should be treated with the gynecologic procedure indicated, whether it be surgery, irradiation, local or medical treatment. Whether the symptom of backache is present or not is of secondary importance when there is definite pelvic disease present. On the other hand, in the presence of a minor gynecologic lesion or displacement the coexistence of the symptom of backache is most emphatically not an indication for surgery unless a causal relationship between the two can be established. Tumors, cysts, marked relaxations and inflammatory masses must be treated surgically. The acute and subacute inflammations are to be treated by chemotherapy or penicillin. Wide cauterization or amputation of the badly diseased cervix may cure the backache caused by the secondarily involved uterosacral ligaments. Frequent hot douches, diathermy and Elliott treatment are of great aid in ameliorating this symptom in the milder inflammatory conditions.

#### UTERINE RETRODISPLACEMENT

Just as the symptom of backache has given rise to controversy concerning its etiology, so has the condition of retrodisplacement of the uterus been a subject of great discussion as to the pathological significance of its existence and the mode of treatment to be pursued. Not many years ago in a great many clinics the mere presence of a retroverted uterus was the only indication deemed necessary for the performance of a uterine suspension. However, as pelvic examination has become a more routine procedure it has been definitely established that many retrodisplacements cause no symptom whatsoever. As a matter of fact, in some quarters it has become quite fashionable to regard the operation of suspension of the uterus as an outdated procedure which is almost never indicated. It is the purpose of this discussion to show that neither of these extreme points of view is



tenable but that the treatment of each case must be individualized. The term retrodisplacement is meant to include the pronounced degrees of retroversion, retrocession and retroflexion.

**Types.**—Retrodisplacements are of three main types, congenital, senile and acquired. The congenital type is present from birth in about 20 per cent of female children. It is quite rare for this type to cause any symptom whatever, since the circulation and the contiguous organs accommodate themselves as development takes place. The normal position of the uterus in elderly women is that of partial retroversion which is a result of atrophy and relaxation of the ligaments and is asymptomatic. The third type is acquired after the organ has previously been in normal anterior position.

The main causes of acquired retrodisplacement are associated pelvic disease, trauma and childbirth. Pelvic inflammatory disease with binding adhesions as well as heavy uterine and ovarian tumors, may cause retroversion. Sudden jarring trauma occasionally causes retrodisplacement of the uterus with back pain. By far the most common etiologic agent of acquired retroversion is childbirth. Approximately 33 per cent of postpartum patients have backward displaced uteri four to six weeks following delivery. A number of these spontaneously assume the normal anterior position in a few months as the tone of the ligaments is again established. Some are entirely without symptoms. However, in a significant number of cases there is a gradual onset of such discomforts as sacral backache, menstrual disturbances and fatigue. These symptoms are thought to be due not only to direct pressure and traction but also to the impediment of the return circulation brought about by this unnatural position, with a resultant engorgement of the uterus and adnexae. In this type of case the organ is enlarged and soft with engorged blood and resembles an early pregnant uterus. It is not unusual to observe large varicose veins in the broad ligaments, and the tubes and ovaries are often prolapsed into the posterior cul-de-sac with injection and edema because of passive congestion. Such conditions lead to abnormal function and, if allowed to continue, to permanent damage of these highly important structures. Retrodisplacement is often a forerunner of prolapse of the uterus and sterility is not uncommon. One of the most dangerous complications of retroversion is the development of associated pathologic processes such as endometriosis, which seems to be increasing in frequency.

**Treatment.**—*Nonoperative.*—The congenital, the senile and the acquired types of retrodisplacement if symptomless should be left alone. It is wise for such a patient to have periodic examinations or to report if symptoms occur. In those with symptoms the uterus should be replaced manually and a pessary, such as the easily available Smith pessary, inserted. If symptoms are relieved for three months the pessary is withdrawn. In a certain proportion of patients the tone of the

supporting structure has been restored, the organ remains in normal ante-position, and the disability disappears. However in others the uterus again becomes retrodisplaced and the symptoms recur. This is

Fig 475

Fig 476

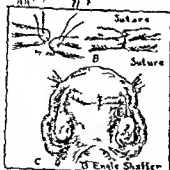
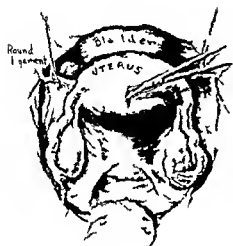


Fig 477



Fig 478

Figs 475-478 - Uterosuspension by subperitoneal approach using the Baldy Webster principle (For description see text)

absolute proof that the discomfort is due to the retroversion and that conservative measures have failed. It is in this group that surgical suspension of the uterus is necessary to effect a cure. Surgical uterine suspension is also indicated in those cases with associated disease which

is severe enough in itself to indicate surgery. For women approaching the menopause and for those whose adnexae must both be removed hysterectomy is the procedure of choice.

*Operative*—There have been many procedures devised for suspension of the uterus. While a goodly number of these technics have been discarded there are still several in use which have given good results. Among the most popular operations today are the Baldy Webster, the Montgomery Simpson and the Coffey. A subperitoneal approach using the Baldy Webster principle is a technic<sup>11</sup> which as yet is not widely known but which gives excellent results without the usual dangers and drawbacks. The technic is as follows:

After anesthesia and proper preparation the lower abdomen is incised in the midline as for any intrapelvic procedure. The retroverted uterus is elevated and held in ante-position. A vertical incision  $\frac{3}{4}$  to 1 inch long is made on the posterior uterine wall its upper end corresponding to the intertubal line (Fig. 475). This incision is very superficial, only the peritoneal covering of the uterus being divided.

With a slender pair of Mayo scissors a subperitoneal tunnel is made in the posterior uterine wall extending to the insertion of the broad ligament on either side. A slender long-nosed curved hemostat is then introduced into the tunnels on either side and the anterior leaflet of the broad ligament is pierced (Fig. 476). The round ligament is then grasped in the hemostat at the point of its greatest mobility and the loop of ligament drawn back through the tunnel until it appears at the uterine incision (Fig. 477 A). This being accomplished on both sides the loops are approximated with one or two sutures of fine silk, linen or catgut depending upon the preference of the surgeon (Fig. 477 B). The vertical incision in the uterine peritoneum is then meticulously closed with very fine catgut and the operation is complete (Fig. 477 C).

It will be noted that the posterior leaflet of the broad ligament is not perforated so that no opening exists through which bowel might herniate nor are there exposed loops of round ligament on the posterior surface of the uterus. There is much less chance of the suspension breaking down because agglutination between the uterus and round ligaments takes place in two long, buried and scarified tunnels.

The uterosacral ligaments may be sutured together following this procedure if it seems efficacious. This operation is also admirably suited for those cases where one of the adnexae has been removed. The usual subperitoneal operation is then done on but one side and the other round ligament is brought over the cornu to peritonealize the raw area left by removal of the adnexa (Fig. 478). The result is a completely peritonealized surface without the torsion or abnormal pull that occurs when such a procedure is done with a Coffey or Montgomery Simpson suspension.

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# THE TREATMENT OF HABITUAL ABORTION WITH ESTROGEN AND PROGESTERONE

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## INTRODUCTION

It is frequently stated that abnormalities inherent in the germ plasma constitute the largest cause for spontaneous abortion particularly since it has been shown by a number of observers<sup>1 2 3 4</sup> that a high percentage of aborted embryos are pathologic. This concept has lost considerable support as pointed out by Meaker,<sup>5</sup> since many of such pregnancies can be saved and carried to term with the birth of normal babies confirming the viewpoint of Mall<sup>1</sup> that these malformations may often result from external factors which have interfered with the growth development or nutrition of the embryo.

Much emphasis has been placed in recent years on the importance of endocrine factors in abortion, particularly those relating to functional failure of the corpus luteum and placenta. A sufficient number of studies are now available from a number of laboratories to indicate that abortion is sometimes preceded by a marked fall in pregnandiol levels pointing toward premature failure of the corpus luteum or inadequate function of the placenta.<sup>6 7 8 9</sup> On the other hand there are also a number of reports that in some normal pregnancies low pregnandiol titers have been encountered while other patients may threaten to abort when pregnandiol titers are normal.<sup>6 9</sup> Finally there are the therapeutic results with progesterone like so many statistics on the treatment of abortion they are impossible of evaluation except to point out that they are conflicting.

In studies which we have made over a number of years on the blood and urine hormonal levels of normal and abnormal pregnancies we have been impressed not only by the high percentage of habitual aborters who exhibit low pregnandiol titers but even more by the frequency with which these are associated with diminished blood and urine estrogen levels. Since both of these hormones are believed to be made by the corpus luteum during early pregnancy these findings would support the diagnosis of premature failure of this structure.

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but since this same type of double-deficiency was often noted by us after the first trimester we were led to believe that the placenta can be equally responsible for the failure to produce estrogen and progesterone. These findings have encouraged us during the past three years to treat our habitual aborters with combined estrogen-progesterone therapy, despite early misgivings which we had concerning the administration of estrogens to patients who were threatening to abort or miscarry. During this time there appeared a report by Hamblen and co-workers<sup>6</sup> that progesterone alone failed to elevate low pregnandiol titers and to prevent abortion, and that in a few cases the addition of estriol glyceruronide did not help. More recently Hamblen states,<sup>7</sup> "We believe that 'synergism' of progesterone with estrogen is advisable" and have employed it in the treatment of abortion.

## CLINICAL AND LABORATORY DATA

**Patients.**—The present study was made on a group of twenty-four women seen by us during the past three years in whom the previous

TABLE 1—OBSTETRIC HISTORIES

Total number of patients	24
Total number of previous pregnancies	80
Abortions	52
Miscarriages	18
Stillbirths	2
Premature live births (did not survive)	1
Full term live births (all normal)	7
Para 0 = 20	Grav 3 = 11
Para I = 2	Grav. 4 = 7
Para II = 1	Grav. 5 or more = 6
Para III = 1	

two or more pregnancies terminated in abortion or miscarriage. These patients had gone through a total of eighty previous pregnancies (Table 1) from which there had resulted only seven (9 per cent) full term living infants, despite various types of treatment in many of the pregnancies. There were fifty-two abortions, eighteen miscarriages and one premature baby which lived only a few minutes. Twenty of these twenty-four women had no living babies. Eleven women were pregnant for the third time, seven for the fourth time. In one patient seven previous pregnancies had resulted in abortion at the eighth to tenth weeks. One patient pregnant for the twelfth time had two living children, five abortions and four miscarriages.

The ages of these patients ranged from 21 to 36. Fourteen women were less than 30 years of age.

A detailed analysis of the family and past medical histories of these patients did not reveal any factors which might be of etiologic significance. There were no instances in which habitual abortion or mis-

carriage occurred in the mother or in sisters. No patients were included in this study who had pelvic tumors or other local abnormalities which might influence abortion, miscarriage or premature labor.

**Menstrual History and Fertility**—The menstrual histories of these patients were remarkably good (Table 2) and compare favorably with other similar groups of normal women. In seventeen or 71 per cent of the cases no marked deviation from normal was recorded. In six cases episodes of hypermenorrhea, oligomenorrhea or short periods of amenorrhea had occurred and one patient had a mild degree of menorrhagia.

From the standpoint of fertility (Table 2) thirteen or 54 per cent of this group were able to become pregnant each time in less than six months and were classified as being of good fertility.

Two patients required from six months to a year to become pregnant and were classified as of diminished fertility, while nine patients were considered to be of poor fertility because they required more than a year for each conception. Four of these patients had been under treatment for sterility problems. The percentage of patients with some

TABLE 2—MENSTRUAL HISTORY AND FERTILITY

	No	Percentage
Normal menstrual history	17	71
Menstrual irregularity	6	2
Menorrhagia	1	4
Good fertility	13	54
Impaired fertility	2	8
Poor fertility	9	38

impairment of fertility was probably somewhat higher in this group than average. There was however no correlation noted between degree of fertility and tendency to habitually abort. The patient with seven abortions was married less than three years.

**Studies Prior to the Present Pregnancy**—Fifteen of the twenty-four patients were seen before the present pregnancy began. In addition to careful physical examination the following studies were made on these patients in as many instances as possible: Wassermann, Rh factor, basal metabolic rate, sounding of the uterine cavity, study of the endometrium obtained by endometrial biopsy or dilatation and curettage, urine hormone assays including gonadotropins, estrogens and pregnandiol. In the husband the basal metabolism test, Rh test and a semen study were made. In the nine patients who were already pregnant some of these studies had previously been made. Many of these tests, particularly the basal metabolism and hormone assays, were repeated during pregnancy.

**Wassermann Test**—The Wassermann and Kahn reactions were negative in all twenty-four of these cases and were also found to be negative

ive in all of the husbands. There was no history of antiluetic therapy in any of the patients.

**Basal Metabolism**—None of our patients exhibited frank clinical evidences of thyroid dysfunction such as thyrotoxicosis or myxedema. The pre-pregnancy basal metabolic rate in all our patients was within the commonly accepted range of plus or minus 15 except one in whom several tests averaged minus 20 (Table 3). She presented no distinct clinical features of hypothyroidism and had a normal serum cholesterol, but because of the hypometabolism she was regarded as 'hypothyroid'. Only six patients had an average basal metabolic rate of less than minus 5.

TABLE 3—STUDIES PRIOR TO PREGNANCY BASAL METABOLIC RATE  
(AVERAGE OF TWO OR MORE TESTS)

	No	Percentage
Patients tested	24	
Within plus or minus 15	23	96
Minus 20	1	4
Less than minus 5	6	25

TABLE 4—STUDIES PRIOR TO PREGNANCY RH FACTOR

	No of Cases	Percentage
Rh test on mother	24	
Positive	22	92
Negative*	2	8
Rh test on father	14	
Positive	14	100
Negative	0	0

\* Both husbands Rh positive

Both patients were gravida III (2 abortions each)

**Rh Factor**—A test for the Rh factor was made in all of the twenty-four cases (Table 4). In a majority of the cases the Rh had also been previously taken in this or other hospitals following the last abortion. Twenty two of the patients were found to be Rh positive. Two patients were found to be Rh negative and their husbands were Rh positive. Rh antibody titers were made at monthly intervals during the pregnancies of these two patients but no agglutination occurred in a dilution of 1:1. One of these patients had a missed abortion, the other delivered a full term normal baby. They had each had two previous abortions.

**Examination of the Endometrium**—The endometrium was examined in eleven patients in the premenstrual phase (Table 5). The tissue was obtained by full curettage in two cases and by endometrial biopsy



of at least two sites in nine patients. Urine hormone assays were made in the same cycle.

In two of the cases an interval endometrium was found indicating that in these particular cycles ovulation had not occurred, estrogen and pregnandiol determination were also diminished in these instances. It is probable that in some of these patients with diminished fertility anovulatory cycles are frequent and in two other cases late proliferative changes were obtained with questionable or imperfect secretory function. In both of these cases estrogens and pregnandiol were diminished. In the other seven instances a normal secretory endometrium was obtained. In one instance a marked decidual reaction was noted and this patient was found to have been pregnant at the time the biopsy was taken; fortunately she carried to term.

*Urine Hormone Assays Prior to Pregnancy*—Urine hormone assays were made in fifteen cases (Table 6). A twenty-four hour urine specimen collected at the midcycle was assayed for gonadotropins and estrogens. A forty-eight hour specimen collected one week later was assayed for estrogens and pregnandiol. The methods which we employ

TABLE 5—STUDIES PRIOR TO PREGNANCY: EXAMINATION OF PREMENSTRUAL ENDOMETRIUM (BIOPSY OR DILATATION AND CURETTAGE)

Number of cases	No. Percentage	
	11	
Good secretory function	7	64
Impaired secretory function	2	18
Interval endometrium	2	18

in our laboratory and the results obtained in normal cases have been published.<sup>11</sup>

The gonadotropins were assayed by the mouse uterine weight method on an alcohol precipitate of the urine. Estrogens were assayed on spayed mice in a carbon tetrachloride extract of the hydrolyzed urine. Pregnanediol was determined by the gravimetric method of Venning and Browne.<sup>12</sup>

Gonadotropins were found to be within normal (16 to 40 mouse units) in thirteen or 87 per cent of the fifteen cases. In one case in which there was also an interval type of endometrium the gonadotropins were diminished and in another associated with a normal secretory endometrium a high value of more than 96 mouse units was obtained. We have occasionally noted such high values at the midcycle.

Urine estrogens were found to be within the normal range (32 to 100 mouse units) at both the midcycle and third week in only five or 33 per cent of the fifteen cases. Estrogens diminished below this value occurred in ten or 67 per cent of the cases, in four of these normal values were noted at the midcycle but were low in the second specimen. In nine of the ten instances low values were noted during the

third week, only one patient had a normal third week value and diminished midcycle value

Urine pregnandiol determinations were made in five cases. Values less than 2 mg per twenty-four hours were considered diminished, and were encountered in eight of the patients. In three cases no precipitate at all was recovered. In four of these eight cases the endometrial findings were also abnormal. In seven patients values of 4 to 12 mg of pregnandiol each twenty-four hours were found.

**Hormone Assays During Pregnancy**—Serum gonadotropins, serum estrogens and urine pregnandiol were determined on nineteen patients prior to the onset of treatment. In three instances these studies were repeated at monthly intervals during the course of treatment, while the other patients had at least one additional assay made during early pregnancy. The results given below are based on the initial assay made prior to the onset of treatment. It has been our routine to consider values less than 50 per cent of our average normal as diminished.

TABLE 6—STUDIES PRIOR TO PREGNANCY HORMONE ESSAYS

	No	Percentage
<i>Urine gonadotropins</i> (midcycle)	15	
Within normal	13	87
Diminished	1	7
Excessive	1	7
<i>Urine estrogens*</i> (midcycle and premenstrual)	15	
Within normal	5	33
Diminished	10	67
<i>Urine pregnandiol*</i> (premenstrual 2 assays)	15	
Within normal	7	47
Diminished	8	53

\* Eight (53 per cent) of the fifteen patients had a combined estrogen and pregnandiol deficiency.

**Serum Gonadotropins**—Serum was assayed for gonadotropic hormone in infantile mice by determining the least amount necessary to produce corpora hemorrhagica or corpora lutea in two thirds of the mice and compared to the normal range previously published from our endocrine laboratory. In eighteen cases or 95 per cent the values fell within the normal range. One patient showed diminished gonadotropins at six weeks, had an episode of spotting several weeks later but went on to full term.

**Free Serum Estrogen**—Free serum estrogens were determined in whole serum by studying the histologic response of the vagina of the castrate mouse to varying amounts of serum. Results were compared to normal values in the period of gestation previously obtained in our laboratory. Diminished estrogen values were obtained in 15 of the 19 patients studied. In only four instances were the estrogen values considered to be within the normal range. The serum estrogen values made at approximately monthly intervals are shown in Figure 479.

**Urine Pregnanndiol**—Sodium pregnanndiol glucuronide was determined by the gravimetric method of Venning and Browne<sup>12</sup> on com

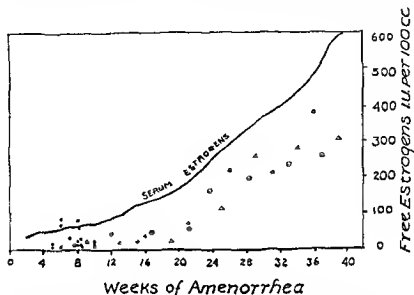


Fig 479—Free serum estrogen values in habitual aborters. The curve indicates the normal average free serum estrogen levels. The black dots are the initial values in the nineteen patients studied. The circles, the circled dots and the triangles indicate the results of repeated assays on these three patients.

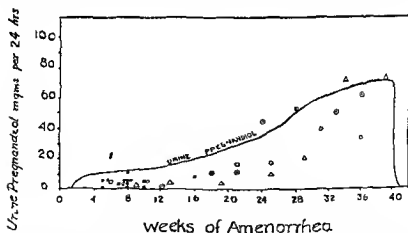


Fig 480—Pregnanndiol values in habitual aborters. The black dots indicate the initial values in the eighteen cases studied. The other figures are the results of the repeated values on the same three patients who were studied for free serum estrogen.

plete twenty four hour urine specimens in eighteen cases. Fifteen of these patients showed pregnandiol levels which were diminished to 50



tinued to term in eight cases. In six of these, patients fell into labor while they were still under treatment. One patient had treatment only for three weeks at which time she aborted. Wherever possible treatment was continued at least to the twentieth week of gestation. The duration of treatment was adjusted as a rule to run beyond the time when the patient generally aborted or miscarried. Patients who had late miscarriages in previous pregnancies were generally given injection three times weekly as they approached the usual time for miscarriage.

No untoward local or general reactions to therapy were observed.

No vitamin E or other vitamin therapy was given except for the usual mixed vitamin capsule containing the minimal daily vitamin requirement which many of these patients were in the habit of taking. None of the patients were confined to bed except during episodes of bleeding, backache or other symptoms suggestive of possible beginning miscarriage.

TABLE 8—RESULTS OF TREATMENT

	No.	Percentage
Total number of pregnancies	24	
Full term live births	15	62
(1 neonatal death due to congenital abnormalities)		
Premature live births	3	12
(2 survived)		
Miscarriages	7	8
Abortions	4	17
Total number of living healthy infants	16	67

## RESULTS OF TREATMENT

Fifteen of the twenty-four patients had full term live births (see Table 8). All of these patients had spontaneous deliveries without any unusual complications during labor. Of the fifteen pregnancies four of the infants were entirely normal and survived. One patient (A.R.) delivered a full term living infant with multiple congenital abnormalities including an imperforate anus and polycystic kidneys which died within twenty-four hours. This patient had two previous abortions and one early miscarriage. A number of Rh studies were made during her pregnancy because of conflicting results by different laboratories as to whether she was Rh positive or Rh negative. Blood was sent to Dr. Philip Levine who reported that she was Rh positive but of a rare subtype. Her husband was Rh positive. No antibody titer developed during pregnancy and the baby at term was not jaundiced or erythroblastotic.

Three patients delivered premature living babies at about seven lunar months' gestation. One of these weighed four pounds, was distinctly immature and survived for only a few minutes. The other two premature babies survived and were otherwise normal.

Of the four patients who had normal serum estrogens and urine pregnandiol three had normal living babies, the fourth was the patient referred to above (A R) whose baby died neonatally because of congenital abnormalities. Since these three patients did not have hormone assays made after the first trimester it is not known whether they developed estrogen and progesterone deficiencies later.

Three patients who had low estrogen and progesterone values on their first assay during the early weeks of gestation and who were treated with estrogen and progesterone were followed at approximately monthly intervals by repeat hormone assays (Figs 479 and 480). It will be noted that despite treatment the hormone values did not return to normal. During late pregnancy there was a tendency for occasional assays of estrogen and progesterone to be within the normal range.

### REPORT OF CASES

**Successful Cases**—Among the cases which were successfully treated during this pregnancy the following merit special description.

**CASE I**—C K, aged 24. The past medical history and menstrual history of this patient was entirely normal. The patient married in June, 1940, and became pregnant in October. She miscarried spontaneously in December. By February, 1943, she had had a total of seven spontaneous abortions at approximately eight weeks of gestation in each instance. During six of the pregnancies she received progesterone which in the last two pregnancies was given in a dosage of 20 mg a week. She also received vitamin E in most of these pregnancies and in three of them received thyroid extract despite the fact that the basal metabolic rate was always normal.

Physical examination was entirely negative. The Wassermann test was negative. The patient and her husband were both Rh positive. The basal metabolic rate was plus 9. Semen analysis was normal. Endometrial biopsy made in the last week of the seventh cycle following her seventh abortion showed a secretory endometrium with a marked decidual reaction. Urine hormone assays made during this week showed pregnandiol 2 mg per twenty four hours and diminished estrogens (22 mouse units per twenty four hours). When the menses failed to arrive at the expected date a Friedman test was made one week later and found to be positive.

The patient was immediately placed on progesterone 10 mg., and estradiol 10,000 rat units, three times weekly which was continued until the twenty sixth week and then reduced to twice weekly. She showed repeated hormone and pregnandiol titers with normal gonadotropins. The same treatment was continued except that, after the twentieth week, injections were increased to three times weekly and were continued to the thirty second week of gestation. Two weeks later she delivered an apparently full term normal living baby. Hormone assays made at the twentieth and twenty-eighth weeks of gestation showed normal pregnandiol and estrogen titers.

**CASE II**—M N, age 26, Gravida IV, Para 0. Physical examination was negative except for moderate obesity. Menses were quite irregular, recurring at four to six week intervals. The patient was of poor fertility and was treated with thyroid extract and gonadotropic hormone prior to the first pregnancy which terminated in a spontaneous abortion at ten weeks. She became pregnant again two years later after treatment with thyroid and progesterone and received injections

of progesterone, 10 mg weekly until the time of miscarriage at fourteen weeks. Two years later she again became pregnant. Several months before her third pregnancy she showed diminished estrogens and pregnandiol during the last half of the cycle. Her basal metabolic rate was minus 10. The patient and her husband were both Rh positive. A semen analysis was normal.

Hormone assays made at the sixth week of gestation showed diminished serum estrogens, diminished urine pregnandiol and normal serum gonadotropins on two assays. The patient received injections of progesterone 10 mg and estradiol 10,000 rat units twice weekly until the twenty-fourth week when she delivered precipitately at home. The baby weighed four pounds but lived only a few minutes. At autopsy it was found to be normal except for prematurity and immaturity. The placenta was grossly and histologically normal.

This patient subsequently became pregnant again the following year. Hormone assays made at six weeks of gestation again showed low estrogen values and assays made at the twelfth week of gestation continued to show diminished pregnandiol and estrogens but normal gonadotropins. The patient had an episode of bleeding at six and one-half lunar months which stopped in several days and she was finally delivered at term of a normal baby. The placenta was found to be normal in histologic examination.

**Unsuccessful Cases**—A total of six babies were lost during pregnancy by abortion or miscarriage, four in the first trimester, two in the second trimester.

**CASE III**—M. G. had two previous abortions. She was first seen for this type of treatment at six weeks of gestation after bleeding had already started and received three injections a week for six weeks. Her basal metabolic rate was minus 6. Estrogen and progesterone values three months before pregnancy occurred were diminished. No hormone studies were made during pregnancy. She spotted throughout and finally miscarried at twelve weeks. During her second pregnancy she had received progesterone therapy 10 mg twice a week until time of abortion.

**CASE IV**—S. H. had one previous stillbirth cause unknown and two abortions. Dilatation and curettage six months before pregnancy showed a normal secretory endometrium and normal estrogen and progesterone excretion during the last half of that cycle. However hormone assays made at the fifth week of gestation showed normal serum gonadotropins with diminished estrogens and pregnandiol. This patient started treatment at the fifth week, received injections twice a week and miscarried suddenly without preliminary symptoms at the fourth week. She also received thyroid extract grain 1 during this pregnancy.

**CASE V**—H. K. age 29 had two previous abortions. She was Rh negative. Her husband was Rh positive. Hormone assays made two months before pregnancy showed normal estrogen and progesterone excretion but assays repeated at the third week of gestation showed diminished estrogens and pregnandiol and normal gonadotropins. Treatment was started at the third week of gestation and she was given two injections weekly. After the tenth week the uterus failed to enlarge. At the twelfth week the pregnancy test was negative and the patient aborted the following week. No Rh antibody titer developed during this pregnancy. She had received progesterone in her previous pregnancies.

**CASE VI**—F. P. age 22. Gravida III. This patient had two previous abortions. Basal metabolic rate before pregnancy was consistently low (average minus 20). No hormone studies were made before pregnancy. Assays made at the eighth week of gestation showed diminished estrogens and pregnandiol and normal serum gonadotropins. The patient received thyroid extract 2 grains daily. In

jections of estrogen and progesterone were started at the eighth week and given twice weekly. The patient aborted four weeks later.

**CASE VII—E. R.,** age 26, Gravida III. This patient had two previous abortions. She had previously been treated with chorionic gonadotropin to correct menorrhagia believed to be due to a corpus luteum deficiency. Treatment was started at the tenth week after bleeding had already begun and the patient aborted after three injections. She had been treated with progesterone and vitamin F in her last pregnancy.

**CASE VIII—E. S.,** age 34, Gravida IV. First pregnancy resulted in a normal living baby and was then followed by two abortions. Her menstrual history was irregular and of poor fertility. Injections twice weekly started at the fourth week. The uterus failed to grow after the eighth week and the contents were expelled at four months. She had received progesterone and vitamin E in her last pregnancy.

Among the twenty-four cases comprising this study there was a total of eighteen live births with survival of sixteen living healthy infants making a fetal salvage average of 67 per cent.

#### COMMENT

**Endocrine Factors in Habitual Abortion and Miscarriage**—It is generally conceded that the corpus luteum in the human and in certain other species is essential for pregnancy by producing changes in the endometrium favorable to nidation, growth and development of the fertilized ovum and by inhibiting uterine contractions during the period of implantation and the early weeks of gestation. This is accomplished largely through the action of the corpus luteum hormone progesterone. It is important to recall, however, that the corpus luteum in addition to making progesterone makes considerable amounts of estrogens. These two hormones are intimately dependent upon each other in producing their physiologic effects. Estrogen is necessary to prime the uterus for the action of progesterone in producing a normal secretory endometrium. On the other hand, progesterone inhibits the excessive destruction of estrogens and facilitates the conversion of estrone to estriol.<sup>13</sup> There is also reason to believe that unless estrogen and progesterone are present in the proper proportions inhibition of uterine contractions will not occur and that, as a matter of fact, a predominance of either hormone may destroy the delicate balance necessary to maintain uterine quiescence.<sup>14</sup>

It is known that in the human the corpus luteum is functionally active only during the early months of gestation. According to results following bilateral oophorectomy during pregnancy, the corpus luteum is generally essential for the normal continuation of gestation during the first trimester. Occasional pregnancies have persisted despite the removal of the ovaries even in the very early weeks of gestation.<sup>15, 16</sup> The functions of the corpus luteum in making progesterone and estrogen are gradually taken over by the chorioplacental system.<sup>8</sup> It is not known with certainty which cells make the estrogens and proges-



terons but it is believed on indirect evidence<sup>17</sup> that both hormones are made in the syncytial cells of the placenta. During the early weeks of gestation the excretion of estrogen and progesterone in the urine rises but very slowly. It is not until about the eightieth day that the pregnandiol level rises distinctly above the level of 10 mg—its peak in the corpus luteum phase of the normal cycle. Estrogen excretion after this period is also considerably higher than at any time of the normal menstrual cycle. Throughout the remainder of pregnancy the estrogen and progesterone curves roughly parallel each other. A few weeks before the onset of labor a large amount of estrogenic hormone which had up to this time been present almost entirely in the conjugated state now becomes freed,<sup>18</sup> indicating important metabolic changes probably preparatory to the onset of labor. There is also some evidence that shortly before the onset of labor there is a sudden drop in the pregnandiol level.<sup>19</sup>

In reviewing the hormonal physiology of normal pregnancy it is apparent that there are three phases in which deficiencies in estrogen and progesterone may develop: (1) during the immediate postovulatory phase when the corpus luteum may be inadequate because of insufficient pituitary gonadotropic stimulation or abnormalities resident in the ovary, (2) the phase of the corpus luteum of pregnancy, which may be inadequate either because of insufficient chorionic gonadotropic stimulation or local factors in the corpus luteum or ovary, (3) the placental phase, with inadequate production by the placenta after normal or premature failure of the corpus luteum of pregnancy.

Very little is known concerning failure of the corpus luteum immediately following conception. Studies of the endometrium showing poor or "immature" progestational response have been reported<sup>20</sup> but have been held open to question. In our present series there were two such instances of an "early" secretory endometrium. Moreover more than half of the group of fifteen patients studied prior to pregnancy had low urinary estrogens at the midcycle and during the third week with diminished pregnandiol at the latter time. We are of course well aware of the dangers of attempting to draw conclusions from isolated hormone assays made on two occasions during one cycle; on the other hand the findings are quite distinct from those commonly found by us in normal cases. If this syndrome of very early placental failure exists, undoubtedly there are many cases of very early abortion which go unrecognized.

The great majority of pregnancies are spontaneously lost during the first trimester when the bulk of the estrogen and progesterone is being produced by the corpus luteum of pregnancy. It is probable that the enormous amount of chorionic gonadotropin which is being produced at this time is largely responsible for maintaining the function of the corpus luteum. It would seem that deficiency of chorionic gonadotropin is not a frequent cause of corpus luteum failure since it

was below the normal range in only one of nineteen cases tested in our series. It is only when death of the fetus has been suspected that the chorionic gonadotropins begin to drop and do so quite precipitously. In our experience when the serum gonadotropins have fallen to less than 100 mouse units per 100 cc. of serum the fetus is usually non-viable.<sup>21</sup> Administration of chorionic gonadotropin would therefore not be rational therapy as a rule, furthermore the amounts required in terms of the quantity being produced in early pregnancy would be quite enormous.

The interpretation of diminished pregnandiol determinations in habitual aborters has been made difficult by the observation of diminished values in normal pregnancies.<sup>6, 9</sup> We have also had the experience mentioned by others of a normal live birth following periods when very little or no pregnandiol was excreted on repeated examinations.

In our experience serum estrogen values are much less subject to the marked day to day fluctuation which may be encountered in urinary estrogen values during pregnancy.<sup>22, 23</sup> probably because the estrogens in the blood of pregnancy are largely present in a free state<sup>24</sup> and are not subject to the metabolic changes which occur in the kidney. In our experience a low serum estrogen value coupled with a low urine pregnandiol is of considerable more significance than the latter alone.

*Rationale for the Addition of Estrogens to Progesterone in the Treatment of Habitual Abortion*—1 Progesterone and estrogen are believed to come from the same sources throughout gestation and their concentrations throughout gestation roughly parallel each other.

2 It is logical to assume that a deficiency in progesterone would be accompanied by a deficiency in estrogen.

3 In our experience such double deficiencies of estrogen and progesterone frequently occur in abortion patients often appearing early in the gestation and persisting in many cases throughout the period of gestation.

4 There are good reasons to believe that estrogen and progesterone influence the normal reactions of each other upon the uterus and are involved in the normal metabolism of each other.

The early objections to the use of estrogen in abortion patients were chiefly on the basis that estrogens tend to increase the tonus and irritability of the uterus and to favor pelvic congestion. These statements can no longer be accepted as a generalization. Indeed estrogens in large dosages throughout a large part of pregnancy have been administered with impunity to many patients for the treatment of diabetes complicating pregnancy. On the other hand, estrogen in large dosage given to patients with missed abortion and intrauterine fetal death is frequently known to start uterine contractions. We have not been able to bring ourselves to believe that the use of estrogens

alone in patients who are threatening to abort is physiologically sound or rationally indicated

**Endocrine Therapy**—There are many reports of a high percentage of successful results following the use of progesterone alone in the treatment of threatened or recurrent abortion. On the other hand there have been an increasing number of studies in the past several years which have raised serious doubts as to the efficacy of progesterone as compared to similar groups who have not received endocrine therapy.<sup>26, 27, 28</sup> Some clinicians have even expressed the opinion that in threatened abortion the administration of progesterone sometimes seems to precipitate expulsion of the products of gestation. Hamblen<sup>6</sup> has suggested that progesterone administration may be undesirable because of possible inhibition of normal progesterone production and metabolism since he has noted that the excretion of pregnandiol was not increased and occasionally was even diminished following progesterone therapy.

Our own results with progesterone alone even in dosages of 40 mg per week have not been very encouraging. Many of our failures with progesterone therapy are represented in the previous pregnancies of some of the patients represented in this study. The poor results of progesterone therapy in this group cannot of course be considered representative of our general experience with progesterone since these cases were selected for further treatment because they were habitual aborters. There were however a number of patients in this group whom we had treated repeatedly in previous pregnancies with large dosages of progesterone without success in any instance.

If the administration of estrogen and progesterone in the dosage which we have employed constitutes complete replacement therapy it might be expected that during the course of therapy the urine pregnandiol levels and serum estrogen would return to normal. Our observations on this point are rather disappointing. In three cases in which we have made observations at monthly intervals normal levels did not occur until late in gestation when the effects of administered hormone would have comparatively less influence on the high estrogen progesterone levels. These observations raise the questions as to whether the dosage we employ is sufficient, whether the mode of administration is the best and whether these patients may not have some abnormality of estrogen progesterone metabolism. The last possibility deserves particular consideration in view of the fact that some of our patients exhibited low progesterone and estrogen levels in both the corpus luteum and placental phases.

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## UTEROSALPINGOGRAPHY

C M SPANGLER, M D \*

THE earliest attempts to visualize the uterine and fallopian tube cavities were made by Rubin in 1914 when he experimented with colargol. Its use was abandoned due to its irritant action on the peritoneum.

In 1922 Sicard and Forestier introduced lipiodol utilizing it initially in the localization of lesions of the central nervous system. Fosdike in 1925 employed lipiodol for the visualization of the uterus and tubes with very satisfactory results, especially in the diagnosis of sterility. Subsequently there were numerous reports submitted by a series of investigators substantiating the value of this diagnostic procedure.

With the lapse of time and the acquisition of experience, however, certain objectionable features were demonstrated to be inherent in the use of this method, namely (1) accidental injection of vessels into which the oil penetrated, (2) oil embolism, (3) nonabsorption of the oil from the peritoneal cavity, and (4) acute peritonitis with abscess formation. Subsequently other radiopaque media such as diodrast, skiodan and uroselectan were utilized in the hope of overcoming the objections offered by the oily medium. These, however, being watery solutions, lacked the viscosity desired in the medium to supply a sufficient body for a constantly satisfactory hysterosalpingogram.

Titus utilized acacia in skiodan with very satisfactory results since in his opinion it lacked the disadvantages of an oily solution and at the same time provided a medium which remained in the uterus and tubes thirty to fifty minutes longer.

The choice of the radiopaque substance utilized is in my opinion not as important as the care and technic of administration.

### INDICATIONS AND CONTRAINDICATIONS

Uterosalphingography is employed (1) to demonstrate congenital abnormalities of the uterus and fallopian tubes, (2) to show the location of uterus and fallopian tubes in relation to other pelvic masses, (3) to outline the contour and content of the uterine cavity, and (4) for the localization of the site of tubal obstruction which has been previously established by repeated Rubin tests. This is the procedure in which uterosalphingography is of most value.

Contraindications include (1) acute vaginitis, endocervicitis or any acute pelvic infection, (2) inflammatory pelvic masses, (3) menstrua-

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tion, (4) pregnancy, whether uterine or extrauterine, and (5) cardiovascular, pulmonary and other serious systemic diseases

#### RUBIN TEST FOR TUBAL PATENCY

No effort to determine the patency of the fallopian tubes should be made with an opaque medium before a Rubin test has been done. This consists in introducing air or carbon dioxide by means of a cannula through the cervical os, into the uterine cavity. The cannula is equipped with a metal collar or rubber nipple to prevent the reflux of air or gas. It is held firmly in position by using tenacula on each side of the cervical os, attaching them to the cannula or holding them manually and making counterpressure with the cannula. Gas is then introduced under known pressure, using a manometer directly or the more elaborate apparatus which produces a kymographic record.

The pressure should not be over 180 mm of mercury. A gradual fall of the manometric reading, in the absence of any leak in the gas circuit indicates the patency of the tubes. This can be further verified by listening with a stethoscope over the suprapubic area. A rumbling or bubbling sound accompanies the escape of the gas through the tubal ostia. On arising the patient experiences pain in the right shoulder less often in the left. This is due to subdiaphragmatic irritation caused by the accumulated gas.

When using a kymographic tracing the characteristic curve of a patent tube is depicted.

Most observers feel that the free passage of gas at 120 mm of mercury indicates a normal patency. Readings above this could mean a temporary spasm of the tube or possibly some partial obstruction. Occasionally, however, the pressure may be sustained for a period of four to five minutes and then begin to decline. This would indicate the separation of minor tubal adhesions or the relaxation of a tubal spasm. Should there be no change in the reading it should be repeated after giving the patient an antispasmodic drug such as atropine sulfate, 1 grain  $\frac{1}{50}$ .

In the presence of normal tubal patency, there would be no indication for uterosalpingography except for the determination of factors relating to the uterus or adjacent pelvic content. The latter can usually be more accurately estimated by careful bimanual examination.

The preferable time for insufflation of the fallopian tubes is within the first week following the menses. At this period the endometrium has been restored and pregnancy is least likely to exist.

#### TECHNIC OF UTEROSALPINGOGRAPHY

The patient is carefully prepared as if for a vaginal operation. The cervix and cervical os are treated with an antiseptic and the cannula is introduced with the curvature of its tip following the direction of the uterine cavity.

Care is taken to have the metal collar or rubber nipple so placed that the opening of the cannula comes just within the internal os. It is secured in position by attaching the tenacula which have been placed on each side of the cervix or by holding the tenacula and making counterpressure with the cannula.

The opaque medium which has been previously warmed to body temperature is placed in a sterile syringe.

If the patient is not already on the roentgen ray table she is moved thereon and the fluoroscopic screen is brought into position. After visualizing the lower abdomen under the fluoroscope and noting the cannula in situ the operator attaches the syringe and slowly injects



Fig. 481—Uterine salpingography showing bilateral occlusion of the oviducts.

the opaque substance. Normally 5 to 8 cc. is adequate unless the uterus is large or the tubes are dilated in which case 10 to 20 cc. may be necessary. The opaque substance is thereby introduced under direct observation. Any obstruction in the cornual or distal portion of the tube is noted (Fig. 481). If the tubes are patent the medium can be seen to continue to the distal end and spill into the pelvis (Fig. 482).

In the event that the tubes are occluded the site of occlusion can be established by stereoscopic x-ray pictures taken at this time. Other abnormalities of the tubes and uterus are also confirmed.

The amount of pressure exerted can be determined by the expression of discomfort on the part of the patient or by means of an interposed manometer between the syringe and the cannula. At no time



Fig 482—Salpingography showing the left tube patent the right hand had previously been removed. The left tube demonstrates patency following the author's operative procedure shown in the paper on Operations for Sterility.



Fig 483—Uterosalphingography demonstrating a right hydrosalpinx. should it exceed 200 mm of mercury. It is hardly necessary to use a manometer provided one refrains from increased pressure as the



medium is observed to cease in its progressive flow into the uterine or tubal cavities

After the x ray pictures are made a recheck under the fluoroscope is advisable to note any change in the original observations

The patient is kept under surveillance for one or two hours and asked to return in twenty four hours for a recheck by x ray At this time the characteristic distribution of the oil over the pelvis can be noted if the tubes are open

Occasionally at the end of twenty four hours unmistakable evidence of oil may be found in the pelvic cavity in instances where fluoroscopically the tubes appeared occluded

The evidence of the medium as a rule is completely dissipated within ten days unless it has become encapsulated in the peritoneal cavity or incarcerated in closed fallopian tubes (Fig 483) An exception arises following the use of a water soluble medium

Iodized oil in the presence of a hydrosalpinx appears as globules due to the difference of the surface tension of the two liquids

## OPERATIONS FOR STERILITY

C M SPANGLER, M D \*

THE surgical approach to the problem of sterility in the woman of childbearing age has been greatly abetted by the introduction of tubal insufflation and uterosalpingography. By these means the confirmation of an absolute sterility is definitely established and its solution approached.

While it is a fact that to date this challenge cannot be met with too great enthusiasm, yet there are circumstances which warrant every effort, provided the patient has been thoroughly acquainted with possible problems which must be faced, and led to realize that regardless of the apparent perfection of the operative procedure conception cannot be assured.

### SELECTION OF PATIENT

It is assumed that the patient is in the childbearing age and that the husband has been found capable of producing normal spermatozoa in adequate numbers.

A careful history is taken to ascertain, if possible, the cause of sterility and its duration. The commonest etiologic factors for sterility due to tubal obstruction are gonorrhea with its sequelae, abortions, and postpartum endometritis. The presence of acute or subacute pelvic infection contraindicates any operative procedure until the acute process has been adequately treated and there is no evidence by clinical or laboratory examination of its persistence.

Tubal insufflation is performed to confirm the presence of an absolute sterility.

Absolute sterility refers to the fact that conception is impossible due to complete occlusion of the oviducts. Confirmation of this fact is established by means of uterosalpingography, together with the suggestion of the possible site of obstruction. However a true appraisal of the pathologic state cannot be made until a laparotomy is performed.

### CHOICE OF OPERATIVE PROCEDURE

The choice of the operative procedure is dependent upon the location of the obstruction. Obstructions in general may be divided into three groups—those occurring in the outer third of the tube, those in the medial two-thirds and those possessing such extensive abnormality that any reconstructive surgery upon them is futile. It is generally

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evident that an oviduct which has been so ravaged that it has become a large hydrosalpinx, with concomitant destruction of the muscularis and ciliated mucosal layer, likewise falls into this latter group. Even though the obstruction can be overcome by surgical means the physiologic function of the tubes has been destroyed so that even if patency ensues, there is a relative sterility replacing an absolute one.

1 **Extensive Tubal Obstruction**—In this group any effort to correct sterility must be done by utilizing either the Estes or Tuffier transposition operation. The former (Fig. 484) consists in the excision of the uterine cornu and the attachment of the denuded surface of the ovary

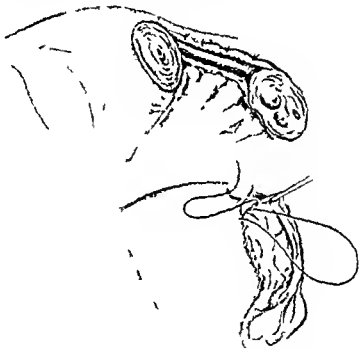


Fig. 484—Estes operation

to the exposed ostium thus established being careful to preserve the blood and nerve supply to the ovary. In the Tuffier operation (Fig. 485) an opening is made into the uterine cavity on the posterolateral wall and the ovary secured in such a manner that it projects into the uterine cavity but does not hang freely therein.

The incidence of pregnancy following these two procedures is not encouraging amounting to but 8 and 4 per cent respectively. However the preservation of ovarian function justifies their adoption especially in the young woman who has been the victim of extensive tubal infection, and in whom the ovaries have escaped the ravages of the disease.

2 Obstructions of the Outer Third of the Oviduct—Occlusions in the outer third may be separated by direct division of the adhesions about the fimbriated end of the tube when these are not too dense. If excessive trauma to the tube occurs it is too often followed by a reestablishment of the obstruction. Under these circumstances it is advisable to employ the circumcision operation suggested by Bonney or one of its modifications, such as that utilized by Sovak (Fig 486). This consists of an amputation of the tube proximal to the site of occlusion. Bleeding is controlled by means of No. 00 plain ligatures. The remaining portion of the tube is then tested for patency with the use of the intrapelvic glass insufflation syringe. If it is patent the air entering the uterine cavity produces a gurgling sound and at the same

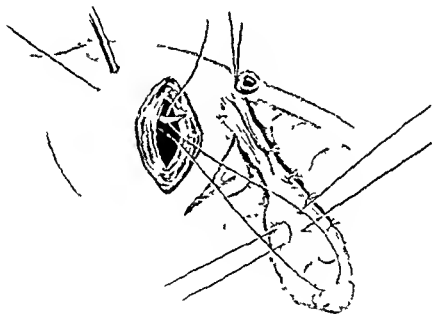


Fig 485—Tuffier's operation

time an impulse to the fingers. With a straight silk catheter (No. 9 French) in the outer third of the tube a Bonney clamp is placed over the tube and catheter 1.5 to 2.5 cm from the amputated end. A circular incision is made at the end of the clamp through the muscularis. Grasping the amputated end of the tube with forceps the operator gently pulls it toward the uterus as counterpressure is made with the Bonney clamp. This everts the mucosa, bringing it onto the serous coat. The cuff is then fixed in this position by fine catgut sutures so that the sutures are secured beneath the cuff. The clamp and catheter are then carefully removed and the patency of the tube confirmed by means of the insufflation syringe. The ovary is then suspended to the lateral pelvic wall to prevent its prolapse into the cul de sac.

In some instances it is feasible to use the simple slitlike incision of the distal end of the tube, everting the two freed edges onto the

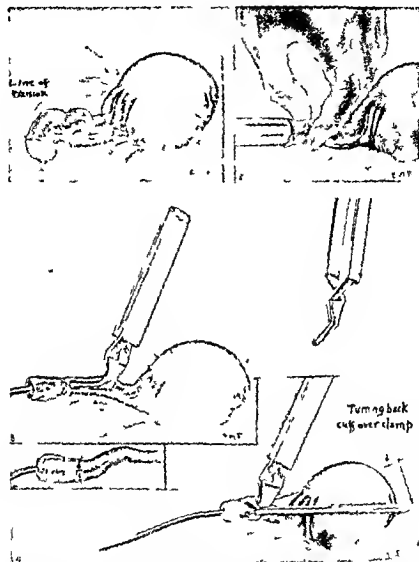


Fig 486 - Circumcision operation for reconstruction of occlusions occurring in outer third of tube Top left Line of amputation proximal to site of occlusion Top right, Testing patency of remaining portion of tube Center, Insertion of silk bougie and application of Bonney clamp 1.5 to 2.5 cm from amputated end Circular incision down through muscularis Bottom Turning back cuff over clamp everting tube Mucosal cuff being brought back to serosa Inset Cuff anchored to serosa Reconstruction complete (From Holden and Sovak Am J Obst & Gynec Vol 24 C. V. Mosby Co)

superior surface and securing them by means of fine catgut or linen sutures The tube and ovary again are attached by means of a fine suture to the lateral pelvic wall to avoid adherence to the pelvic floor

3 Obstructions in the Proximal and Medial Oviduct—Salpingoplasty on the middle and proximal two thirds of the oviduct in my experience offers the greatest opportunity for success. A modification of the

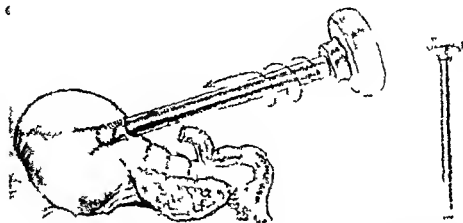


Fig 487—Salpingoplasty. Reaming instrument applied over occluded stump of tube. With a circular movement of the instrument stump of the tube and its intramural port on are reamed out. (From Holden and Sovak. *Am J Obst & Gynec.* Vol 24 C V. Mosby Co.)

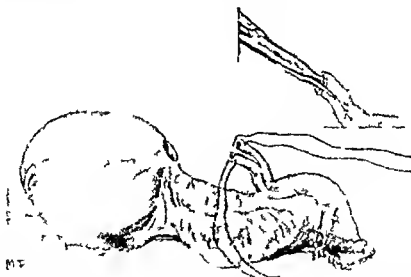


Fig 488—Salpingoplasty. New opening into uterus following removal of occluded tube and its intramural portion. Patent portion of tube bisected longitudinally by cuticle scissors. Long No. 00 chromic sutures applied to superior and inferior ends of bisected tube. (From Holden and Sovak. *Am J Obst & Gynec.* Vol 24 C V. Mosby Co.)

Holden technic (Fig 487-490) is used. The site of tubal obstruction is first determined by means of the insufflation syringe, after which the oviduct is divided distal to the site of the obstruction and the obstructed portion is then freed from its attachment to the broad liga-



Fig 489 Salpingoplasty Insertion of Reverdin needle 1 cm beyond center of fundus posteriorly passing out through the newly created uterine opening in order to bring out the suture previously applied to the end of the superior portion of the bisected tube The same procedure followed by insertion of the Reverdin needle through anterior surface of the fundus (From Holden and Sovak Am J Obst & Gynec Vol 24 C V Mosby Co)

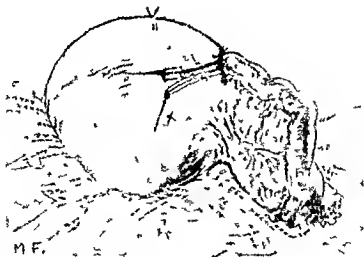


Fig 490—Salpingoplasty By gentle traction on the previously applied anterior and posterior fundal sutures the tube is gradually drawn into the newly created uterine opening and its end into the uterine cavity The sutures are then anchored on the fundus Two or three fine supporting sutures are passed through the serosa of both tube and uterus (From Holden and Sovak Am J Obst & Gynec Vol 24 C V Mosby Co)

went up to the uterine cornu. The vessels in the freed edge of the broad ligament are ligated with plain No. 00 catgut ligatures.

The uterine cornu is excised by means of an elliptical vertical incision which is continued into the uterine cavity (Fig. 491) providing an ostium adequate to accommodate the patent end of the tube. The branch of the ascending uterine artery which is evident at the lower pole of the incision is ligated. The patent portion of the tube is freed of its broad ligament attachment for a distance equal to the thickness of the uterine wall, and a vertical incision is made in its proximal end for a distance of  $\frac{1}{8}$  inch. Mattress sutures are then passed through the

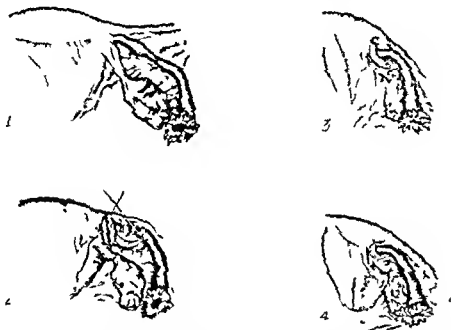


Fig. 491—Author's technique of salpingoplasty. 1 Showing the occlusion of the proximal end of the tube. 2 The occlusion excised, the tube split vertically, and mattress sutures in situ. 3, The suture tied and the tube fixed in the cornu of the uterus. 4, Closure of the elliptical incision with interrupted sutures above and below the ostium.

two flaps so formed and carried under direct observation to the visible endometrium through the uterine wall, one being secured anteriorly, the other posteriorly. Insufflation of the tube is repeated to establish its patency. The opening made into the uterine cornu is then closed by catgut sutures above and below the implanted tube, and its patency reaffirmed.

Postoperative treatment consists in repeating the Rubin insufflation test in ten to fourteen days. At this time, due to local edema, the insufflation test may be negative. However, at the end of six weeks 92 per cent of my series of patients exhibited patent tubes confirmed by the Rubin test and uterosalpingography.



# THE CONTROL OF PAIN AND FEAR IN THE MANAGEMENT OF LABOR AND DELIVERY

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SINCE Pearl Harbor Day, 1941, approximately 12,000,000 babies have been born in the United States. Disregarding multiple pregnancies this number indicates that approximately 24,000,000 people in the United States have been subjected to the hazards, pains and complications of obstetric labor and delivery. Since the great majority of these babies were born to primiparous mothers, most of the labors extended over a period longer than twelve hours. This unprecedented volume of births was managed by a medical profession whose ranks had been depleted by the exigencies of war. Even though the trend in prewar years was away from home deliveries toward hospital deliveries, the crowded conditions of our hospitals in some cities necessitated the delivery of an increased number of babies in the home. Many of the deliveries were attended by midwives, and many of the labors were followed by telephonic reports to busy practitioners of medicine whose patients required almost all their time.

The needs of war have also included the services of many trained physician and nurse anesthetists whose places have been filled in hospitals at home by those less expertly trained and experienced.

Under the circumstances physicians have rendered a magnificent service to these 24,000,000 people. Even in wartime, progress has been made in the safe alleviation of pain. The use of the barbiturates has been extended. Demerol as an efficient and safer substitute for morphine and continuous spinal and caudal analgesia have been introduced. Aviation medicine has taught us much concerning the resuscitation of persons who have lived under conditions of depleted oxygen. The study of such problems has brought about a better understanding of the pathology of asphyxia neonatorum. Prophylactic measures and better mechanical resuscitating apparatuses have been developed. It is now possible to say to physicians returning from the battlefields that pain in obstetrics can be completely alleviated, in many instances, without pharmacologic damage to mother or baby, in many other instances it can be largely controlled.

## HAZARDS CONTRIBUTING TO FETAL AND MATERNAL MORTALITY AND MORBIDITY

Many of the old problems remain. The major complications of labor and delivery, as far as the mother is concerned, are physical and

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emotional fatigue, hemorrhage and delayed convalescence from inept use or overdosage of the pain-relieving agents. From the baby's standpoint, the chief complications are anoxia, hypoxia, profound transplacental narcosis, and obstetric trauma associated with delivery.

In a recent analysis, the late Professor Yandell Henderson of Yale University stated that 150,000 deaths per year in this country alone resulted from combined stillbirth and neonatal deaths due to respira-



Fig 492.—Pain and fear replaced by rest and repose during active labor managed by continuous caudal analgesia

tory complications. In 1941, the last year for which statistics are available, Sage of Nebraska reported fetal and neonatal deaths aggregating 144,692. This is more than the number of deaths occurring among individuals in the age group of 5 to 29 years (99,610) and is 10.4 per cent of the total deaths for all ages and all causes (1,397,642).

Clifford and Irving made an analysis of the factors influencing the condition of the infant at birth. They have listed the following factors:

- 1 Virality of the germ plasm congenital defects and debility
- 2 Maternal abnormality anemia infection dietary deficiency heart disease toxemia
- 3 Fetal diseases syphilis and erythroblastosis
- 4 Fetal anoxemia placental origin gross infarction premature separation placenta praevia
- 5 Fetal maturity at birth
- 6 Factors operating at delivery cephalopelvic disproportion length and type of labor method of delivery normal low forceps mid or high forceps cesarean section version traction suprapubic pressure
- 7 Analgesia morphine barbiturates ether nitrous oxide
- 8 Anesthesia ether chloroform cyclopropane nitrous oxide local spinal caudal
- 9 Skill and experience of anesthetist
- 10 Skill and experience of obstetrician

Darke of New York has presented convincing evidence that the influence of anoxia extends far beyond the first week of a baby's existence. He has analyzed the after results of severely asphyxiated babies from 25,000 deliveries in New York and Philadelphia. By studying intelligence quotients of these babies in early school life and up to the eleventh year as compared with the intelligence quotients of a parent or sibling, he has found that severely asphyxiated babies are as a rule retarded in later life.

H. J. Stander has found that practically every drug that has been administered by mouth, per rectum or by hypodermic, intramuscular or intravenous routes is known to pass into the fetal circulation and the possibilities of a toxic effect when one considers the difference in tolerance to certain drugs in the newborn and the adult maternal organism become evident. In general the effect on the fetus is in direct proportion to the total dosage of the drug or drugs employed, taking into consideration the time interval from administration to delivery. The dangers are always increased in the case of the premature infants. Clifford has ably demonstrated the high mortality rate in such cases where morphine is employed. Furthermore, when we superimpose on this effect the depressing action of an anesthetic which also readily passes into the fetus and the possibility of varying degrees of anoxemia due to depression of the maternal respirations or to cyanosis caused by insufficient oxygenation of the inhaled mixture, the complexity of the situation can be surmised.

The incurred fetal mortality in the United States in 1941 was 5.2 per cent. By the same comparison we could estimate an annual loss of 624,000 babies at birth or during the first year of life. In terms of loss of human life this far exceeds our losses due to war. A recent report from the nation of Brazil indicates that of every thousand births 245 or 24.5 per cent infant deaths occur at birth or during the first year of life.

Not only is obstetric labor and delivery associated with hazards to the newborn but also it is not yet free from danger to the mother.

According to the latest prewar statistics, the United States ranked fourteenth among the nations of the earth in maternal and fetal mortality. Some of this mortality may be attributed to the high percentage of Negro population and the physical disproportions between fetal head and maternal pelvis in the cross marriages between the races. The maternal mortality in the United States in 1941 was 17 per thousand live births. If this same mortality rate prevailed throughout the war years, it means that 20,400 mothers lost their lives during or from complications related to childbirth. This death rate, even though diminishing, is much too high. In a single well staffed American hospital in 1944 three obstetric patients lost their lives as a result of asphyxia from inspirating vomitus under ether anesthesia. The figures still indicate that the morbidity rate for the mother varies from 3 to 10 per cent in most hospitals.

John Elam of Great Britain reported in the British Medical Journal

In 1939 we were making very real progress in our attempts to relieve all women from the pains and misery of labor but during the last five years there has been a wave of shallowness and insincerity passing over our land.

How are we going to explain away this indifference and neglect of the sufferings of their young wives to our returning soldiers, sailors and airmen? Truly our maternity services leave much to be desired. Are we to say to returning warriors who have endured so much, "Oh yes we can help your young wife tremendously, but really it is too much trouble so we are not going to bother." Has then the work of our women in this war been of no account that we must allow this deplorable state of things to continue?"

#### PRESENT STATUS OF PAIN RELIEF IN OBSTETRICS

Against this background of obstetric maternal and fetal mortality and morbidity, it is time that the medical profession should pause long enough to evaluate, without prejudice, the present status of the control of pain and fear in the management of labor and delivery.

McCormick has said "Analgesia is indispensable in the modern conduct of labor and is here to stay. Wisely employed it not only protects the mother against mental and physical shock but likewise enhances the welfare of the newborn infant by guarding it against birth shock. The infant experiences less initial weight loss, suffers less dehydration, and recovers birth weight more promptly.

Not only should physicians devote more attention to the protection of obstetric patients from pharmacologic intoxication or overdosage of the analgesic drugs while attempting to provide a control of pain but also a formerly neglected problem should be brought to the forefront, namely, the psychology of the management of labor and delivery. Recently I made a tour of more than one hundred American cities in each of which I managed the labors and deliveries of women. The psychologic neglect of parturients was appalling. In a great many of the hospitals, less attention was paid to the labor room than to



Fig. 493—Serial facial photographs taken two minutes apart during induction of pain relief with continuous caudal analgesia in the midst of active labor

any other. Most of the labor rooms were too small, overcrowded, equipped with antiquated wrought-iron beds, straw mattresses, and dirty stained sheets. These deplorable conditions were tolerated be-

cause most of the patients were heavily sedated. The influence of the "twilight sleep" era was reflected in the dull gray walls, darkened rooms and peepholes in the doors through which physicians could gaze upon women in "twilight." The rooms were so dark that student nurses, left in attendance to check fetal heart tones and maternal pulses (and to keep the patients from climbing out of bed or injuring themselves), could not possibly discern a maternal cyanosis as an indication of anoxia. From too many of these delivery floors emanate the screams of uncontrolled pain and, of equal importance, unbridled fear.

Since the characters of the labors of multiparas, primiparas and patients presenting complicating abnormalities of physical structure and metabolic efficiency vary considerably, different methods of pain relief should be employed in managing the labor. No one single agent or method is suitable for every case. Many patients reach the delivery floor from their hospital rooms or from their homes thirty minutes before delivery. It would be useless to attempt to relieve these women by methods which require thirty to sixty minutes for adequate pharmacologic action. On the other hand, a great majority of patients reach the labor floor six to twenty hours before delivery. A fairly large number are in false labor or poorly established labor. For these patients it would be folly to institute methods which profoundly narcotize the mother, and, through the placenta, the baby. Too many women are delivered with injudicious combinations of methods of relief. For example, in some clinics it is almost routine to give the patient a modification of "twilight sleep" with barbiturates and scopolamine. If under this management, the patient becomes emotionally excited and physically uncontrolled, she is then given rectal ether with or without paraldehyde. Upon these two narcotizing depressive methods is superimposed a terminal general anesthetic that, in many cases, necessitates a prolonged operative delivery. In such cases, excessive blood loss for the mother and prolonged asphyxia or resuscitative mechanical oxygenation of the baby are self-evident. The bland amnesic and analgesic effect of one (and perhaps two) of these methods could be tolerated by both mother and baby. However, it is the unbroken chain, described as "the works," which contributes so largely to our neonatal and maternal morbidity and mortality. From our experience, we are certain that the combination of a regional method of pain relief, such as caudal, spinal, paravertebral, peridural or pudendal nerve block would act synergistically with the singularly ineffective systemic analgesic. On the other hand, there are cases managed under some form of regional nerve block who become apprehensive, emotionally excitable, and uncooperative. In such cases, emotional as well as physical pain would be controlled by the use of demerol and scopolamine or barbiturates and scopolamine in one of the forms which will be discussed. However, it should be emphasized that there are patients who respond so well to the regional methods of analgesia that

Technics for the Use of Scopolamine with Morphine, Pantopon and Demerol or with the Barbiturates.\*—*Morphine and Scopolamine*—The Boston Lying In Hospital group found that for any method of combined amnesia and analgesia scopolamine is an important drug. The duration of effect on the mother of a dose varying from  $\frac{1}{200}$  to  $\frac{1}{100}$  of a grain is about two hours. As regards the baby it seemed to have no bad effects on fetal respiration. In the past it has been used in combination with morphine given once during labor. Using it in this way amnesia resulted in 39 per cent of the mothers, analgesia in 34 per cent, and there were 27 per cent failures. Excitement occurred in 10 per cent, but there were no respiratory crises. Twenty-three per cent of the babies required resuscitation.

*Barbiturates and Scopolamine*—Used with pentobarbital, which may be taken as a representative of the barbiturates, it was found that amnesia was produced in 86 per cent, analgesia in 14 per cent, and excitement in 17 per cent, with respiratory crises in 0.36 per cent. Three per cent of the babies required resuscitation.

*Demerol and Scopolamine*—As soon as the patient is definitely in labor and complains of her pains she is given intramuscularly 100 mg of demerol and  $\frac{1}{150}$  or  $\frac{1}{100}$  grain of scopolamine. The demerol is repeated routinely in 100 mg doses every four hours and scopolamine is repeated routinely in  $\frac{1}{150}$ -grain doses every two hours. Seventy-two per cent of our patients received complete amnesia, 28 per cent had analgesia (that is, relief of pain), and there were no failures. Three per cent of the patients exhibited excitement. There were no respiratory difficulties and the babies did well. Only one per cent of the infants required resuscitation. As a general routine for a large Lying In Hospital the Boston group rates it as the best agent they have yet used.

H M Kirschbaum of Detroit has used scopolamine alone for the duration of labor and oftentimes for delivery with successful results. The initial dose is  $\frac{1}{100}$  grain of scopolamine, repeated at 30-minute intervals for a total of 3 doses and even in increased doses for desired pharmacologic effect. He states:

There is no uncertainty regarding the action of scopolamine. Individual variations may be anticipated by the sensitivity test. This drug is rapid in action, constant when standardized dosage is used, and easy to administer. With proper precautions, it is safe for both mother and child. Pulse, respiration, blood pressure, and temperature suffer no ill effects from the drug's action. Amnesia is quite complete. We have seen no interference with uterine contractions nor with the normal processes of labor. The mother is not asked to cooperate with the physician or attendants. The contractions continue as they would normally in labor and the patient uses the expulsive forces auto-

\* These methods are used at the Boston Lying In Hospital and Department of Obstetrics of Harvard Medical School under the direction of Dr. Frederick C. Irving, working with Dr. William R. Schumann and Dr. Charles Robie. Quoted from Lull, C. B. and Hingson, R. A. *Control of Pain in Childbirth*, 2nd ed., Philadelphia, J. B. Lippincott Co., 1944.

matically when the head is on the perineum. The loss of blood is minimal and the drug is responsible for a lesser tendency to hemorrhage. Convalescence after scopolamine anesthesia is rapid and smooth. The postpartum course is in no way hampered nor affected by its use. Lactation follows in the normal manner.

**Technics for Securing Obstetric Analgesia and Anesthesia by Rectal Instillations**—Dr. Stephen J. Rudolph, who has worked with Dr. C. O. McCormick and others at the Indiana University Medical Center where there have been several thousand deliveries under rectal ether, has submitted the following technic:

When rectal ether is to be used on a patient in labor, the routine which is to be carried out begins on admission of the patient. After the routine perineal preparation, the patient is given a soda bicarbonate enema. This is a very important point to remember as it has been found that there is practically no postpartum rectal irritation along with diarrhea, etc., when soda enema is substituted for the usual soap-suds enema routine of most hospitals. The patient is then told that when her pains become too severe she may have some capsules which will help her for a while; then when the pains again become severe she will be given something by rectum and that when she is given this rectal injection she is to cooperate and not bear down and to try to hold the medicine just as long as she can. The nurses in the hospital can be responsible for these preliminary instructions, or you can explain your method of analgesia at one of her prenatal visits. However, you will find that a little time taken to explain these seemingly simple facts will be well repaid in having a cooperative and understanding patient who will be satisfied with the method of relief.

The time of administration of medication when using rectal ether may be governed more by discomfort of the patient than with any other means of medication. It is not necessary to await dilatation as long as contractions are hard nor is it necessary to forestall medication because delivery is expected within too short a period (as with morphine, etc.). When the patient first becomes too uncomfortable with pains, she is given nembutal or some other form of barbiturate ( $4\frac{1}{4}$  to 6 grains) orally. Then when she again becomes restless, the first dose of rectal ether may be given. If the patient is very active on admission, both barbiturate and rectal ether may be given simultaneously. The rectal ether holds the patient for various lengths of time from one hour to six hours, with the average of about three hours. It may be repeated after one hour, but this is necessary only in every unusual case. The average primiparous labor requires two to three instillations, while many multiparas deliver after one dose.

There are three possible means of administration of rectal ether: they are (1) simple gravity as with an enema, (2) by pressure using an Asepto syringe, (3) by pressure using McCormick's rectal ether apparatus. There are two standard formulas which are commonly used: (1) plain rectal ether—used in most cases (ether  $2\frac{1}{2}$  ounces, olive oil  $1\frac{1}{4}$  ounces); (2) used only in wild cases who show no relief with No. (1) (ether  $2\frac{1}{4}$  ounces, paraldehyde 2 drachms, olive oil q.s. 4 ounces).

The use of the special apparatus as designed by McCormick is the simplest method and most practicable of all three methods. The least practicable, as can be easily understood, is the simple gravity method because of interference of the presenting part with easy flow of the solutions into the rectum and because time for instillation usually runs into another pain.



In using the machine an ounce of plain olive oil is first placed in the receptacle. This oil flows down through the lower part of the apparatus and remains unmixed with the ether oil mixture which is poured in afterwards.

rectal mucosa and so avoid burning of the mucosa by the ether. It also serves to retard absorption and so gives a more gradual and more prolonged effect. The apparatus is so designed that the total five ounces just fills it to the top.

The patient is then placed on her left side (for a right handed nurse) and the buttocks and thighs are greased well with lubricant to prevent burns which may occur if ether is spilled on the skin and not removed immediately. The apparatus is placed on the bed by the patient's feet and the solution is forced out into the catheter (no air is in the system now). Then with the gloved right index finger the catheter (a No. 22 French) is directed past the baby's head into the lower bowel as high as it can be placed. It is advisable at this point to await the completion of the next pain as the rectal irritation may disrupt the usual uterine rhythm and a pain may be in the offing. After the pain has subsided the ether is injected rapidly and the catheter removed rapidly as soon as all the mixture is in. Firm pressure must then be exerted over the rectum for about ten to twenty minutes especially with each pain otherwise the entire dose will be ejected and of course there will be no effect. The patient is reminded just before instillation that this is the medicine referred to and that she must cooperate by not expelling it.

Administration by means of the McCormick apparatus is simple and in most instances very effective. As mentioned before the average duration of effect of a single dose of rectal ether is about three hours. There are exceedingly few patients who are held only one hour or less and many patients who will go as long as six hours or more and complete delivery (spontaneous) on only a single dose without any other form of anesthesia. If operative delivery is expected a dose of rectal ether about one hour before delivery will lessen considerably the amount of oral inhalations needed.

The effectiveness of any analgesia is not measured by the reactions of the patient at the time but by the amount she remembers later. Despite the fact that the patient can be cooperative throughout her labor and bear down when told etc. it will be found that in most of the cases in which rectal ether is properly used the patient remembers very little if anything about her labor.

The effect of rectal ether on labor has been studied in over 7500 cases delivered in Indianapolis hospitals in recent years. It was found that in most cases labor was shorter than average. When given properly rectal ether serves to relax a rigid perineum and does not stop uterine contractions. The cooperation of the patient in the second stage in pushing down is also advantageous in shortening labor.

The safety of rectal ether analgesia in obstetrics is one of its greatest advantages. In the series mentioned before there was found to be no increase in the number of stillborn. The infants are not wide awake on delivery and respirations are usually delayed for a short period but in most of the cases are easily established (after aspiration of the trachea to clear the air passages) by slight stimulation—spanking, rubbing feet and so forth. Only rarely when rectal ether is used properly are stimulants needed to initiate respiration. The babies usually breathe regularly and cry in one to two minutes.

With regard to maternal safety rectal ether is a reliable form of obstetrical analgesia. Despite the fact that immediately after administration the patient is in deep narcosis or high plane anesthesia there have been few deaths due to the analgesia reported to date.

**Paraldehyde by Means of Oral and Rectal Administration**—Rosenfeld and Davidoff presented a preliminary report on the use of paraldehyde combined with pentobarbital or sodium amytal in fifty cases. To these authors credit should be given for introducing paraldehyde as an amnesic agent in obstetrics. Colvin and Bartholomew of Atlanta recommend 6 grains of sodium amytal by mouth at the onset of progressive labor. They follow this with from 6 to 8 drachms (75 to 30 cc) of paraldehyde as a rectal instillation. They observed that since many labors are characterized by considerable inertia in the first stage it is important to withhold all medication until the pains are less than five minutes apart and are at least of forty-five seconds duration whereas in nulliparas the main problem is to withhold the rectal injection until there is sufficient progress and no evidence of primary inertia. In multiparas, the chief problem is to see the patient in the home or hospital early enough to give an enema and obtain the desired effect from sodium amytal and paraldehyde before labor has progressed too far. The first effect of the injection of paraldehyde may be a slight burning sensation and a desire to expel the solution. From five to ten minutes after the injection hiccups may be noticed. From ten to fifteen minutes after the injection the patient begins to doze lightly between pains and the odor of paraldehyde may be detected on her breath. The following technique is that of Dr. Howard W. Kane of Washington, D. C. \*

1 The patient is instructed to go to the hospital as soon as possible after the premonitory signs of labor appear. The object of the method is to relieve pain and pain alone is the indication for beginning treatment without regard for the condition of the cervix or the character of the contractions.

2 Soapsuds enemas are given until the return is absolutely clear. This is particularly important as fecal matter in the rectum interferes with the absorption of the drugs, causes in effect inadequate dosage and results in restlessness on the part of the patient.

3 The oral dose of paraldehyde for patients weighing up to 170 pounds is 20 cc. Above that 1 cc. is added for each 10 pounds of weight.

4 To one part of paraldehyde is added one part of port wine and one part of water, the usual dose being paraldehyde 30 cc., wine 20 cc. and water 30 cc. This mixture is stirred vigorously to prevent separation into layers of the three fluids.

5 The patient is instructed to hold her breath and to swallow the dose as quickly as possible. There is little taste to the mixture but it is intensely bitter. Several deep breaths and a few sips of tap water remove the burning sensation with surprising rapidity.

6 The average patient becomes definitely drowsy within ten minutes, sleeps between contractions during the next thirty minutes and thereafter is not aroused by the pains.

7 The effect of the initial dose usually lasts from two to four hours. When it is necessary to repeat the medication the original method, paraldehyde, benzyl alcohol by rectum is adopted. In the occasional case in which the

\* The Pathology of Labor, Puerperium and the Newborn. C. O. McCormick, Editor. St. Louis: C. V. Mosby Co. 1944.

patient is still conscious one hour after oral administration, the rectal instillation is given at that time

8 The rectum is irrigated with normal saline solution and the patient is placed upon her left side

9 The minimum effective dose of paraldehyde, by rectum, is 1.2 cc for each 10 pounds of weight of the patient at the beginning of labor

10 The dose of benzyl alcohol is always 1.5 cc. As the action of this drug is largely that of a local anesthetic, the dose does not vary with the weight of the patient

11 To the required amount of paraldehyde is added 15 cc of benzyl alcohol and the mixture is instilled into the rectum by gravity through a funnel and a large catheter which is inserted for a distance of four inches. As the solution disappears from the funnel it is followed by not more than 30 cc of normal saline solution which washes out the catheter and distributes the drugs. The bulk of the injection is so small that instillation can be accomplished between two contractions. While there is little tendency on the part of the patient to expel the solution, it is recommended that during at least four or five pains the buttocks be compressed

12 The dose, and always the full dose, may be repeated if necessary in one and one-half hours. As labor progresses, it will be found that the effect of each successive injection is more lasting, the intervals between repetitions becoming three, four or five hours

13 When several doses of the mixture are given, the rectum should be irrigated with normal saline solution before each alternate instillation

14 To insure the intake of sufficient fluids it is recommended that 1000 cc of 10 per cent dextrose be given, intravenously, every twelve hours

15 Since the patient is not conscious of bladder distention, catheterization should be performed every eight hours

16 Restlessness means that the rectum is not clean, that the effect of the drug is wearing off, or that the presenting part is approaching the perineum. When it occurs during the first stage, the dose should be repeated at the first signs of awakening

A small number of patients vomit almost immediately. In nearly every instance it has been noted that the stomach contained food. Immediately after vomiting ceases, the dose is repeated and the stomach, emptied by vomiting, practically always retains this second dose. In several instances vomiting has occurred twenty or thirty minutes after the paraldehyde mixture has been given. These patients have begun to be affected by the drug and oral administration is difficult. They, therefore, are given the paraldehyde benzyl alcohol mixture by rectal instillation

#### TECHNIQUES TO PRODUCE TOTAL ANALGESIA WITHOUT AMNESIA OR ANESTHESIA

The Malleable Needle Technic of Continuous Caudal Analgesia—1 The patient is placed in the modified left lateral Sims position. The sacral and coccygeal area is cleansed with ether and prepared with one of the antiseptic tinctures. (See Fig. 495.)

2 Bony landmarks used as identification include (a) the inferior tip of coccyx, (b) the sacrococcygeal junction recognized as a palpable or bony protuberance, and (c) the sacral cornua defining the sacral hiatus. The tip of the coccyx is palpated with the middle finger of the left hand, and the thumb is used to find the U- or V-shaped notch indicating the sacral hiatus between the sacral cornua. This is usually

about  $1\frac{1}{2}$  to 2 inches from the tip of the coccyx. In cases in which there was a failure of the inferior sacral arches to fuse into the bony roof of the sacrum, this hiatus may be  $2\frac{1}{2}$  to 4 inches from the inferior caudal tip. Experience with the standard single caudal injections is a desired prerequisite for success in the use of the continuous method.



Fig 494—Osseous and calcareous obliteration of sacral hiatus compared with normal aperture involving 4th and 5th dorsal sacral arches

3. The index or middle finger of the left hand now changes place with the thumb and marks the spot for raising the initial skin wheal.
4. A special apparatus has been developed for this procedure. The analgesic agent recommended by us is 1.5 per cent metycaine in isotonic solution of the three chlorides. Special ampule No. 400 (Lilly) contains this concentration in 200 cc. of sterile solution in a reservoir bottle. When the physician makes up his own solution, we recommend that he use two of the No. 313 (Lilly) one-gram ampules of



Fig 495 —Steps in identifying sacral hiatus and correct injection of anesthetic solution to produce continuous caudal analgesia (See text)

the solution diluted in approximately 125 cc of saline or the three chlorides. With a few cubic centimeters of this solution skin anesthesia is obtained by raising a skin wheal with a 25-gauge needle and deeper infiltration to the sacrococcygeal ligament with a 2-inch 22-gauge needle. Satisfactory ampules containing 1.5 per cent procaine hydrochloride (Abbott) and 0.2 or 0.15 pontocaine hydrochloride (Winthrop) have also been prepared.

5 The special malleable stainless steel 19-gauge needle is now inserted in the midline in the direction of the hiatus at about a 45 degree angle with the skin.

6 As soon as the bevel of the needle pierces the sacrococcygeal ligament, its reinforced metal collar is depressed through an arc of 1 to 3 cm and the needle is thrust slowly and evenly in the midline for 1 to 2 inches within the sacral canal, where its bevel should lie inferior to the lowest extent of the dural sac. This may be ascertained by measuring on the skin with the stilet the approximate extent of the needle. The point of the needle should always be below the level of the second sacral spine.

7 The small section of tubing with special adapter is now slipped over the collar of the needle. The Luer-Lok syringe is securely attached to the adapter. A careful aspiration is performed.

(a) Should clear spinal fluid be obtained, the needle has pierced the dura and lies within the subarachnoid space. In such event the needle should be immediately withdrawn and the case ruled unsuited for caudal analgesia for fear of producing a massive spinal injection of the analgesic drug. Anatomic anomalies with such low lying dura are rare. (In our experience this has happened only eleven times in 3000 injections.) A failure to recognize this situation would be extremely hazardous if not fatal.

(b) The withdrawal of pure blood indicates that the needle has pierced a small blood vessel in the highly vascular peridural space. In this event, the point of the needle should be moved until blood can no longer be obtained. Then the injection is continued cautiously.

8 The danger of intraspinal injection with appearance of spinal fluid previously mentioned can be minimized if a trial dose of 8 cc of the solution is injected and further action delayed for ten minutes to see that a low spinal anesthesia does not ensue. Without relief of pain or diminution of motor power in the lower extremities in ten minutes after injection, one can safely assume that the subarachnoid space has not been entered.

9 After these precautions have been carried out, the hose end of the special four foot tubing is secured over the collar of the special caudal needle. The tubing should previously have been connected to the remainder of the apparatus, all air having been expelled by filling the entire system with metycaine solution.

10 With the palm of the left hand firmly pressed over the skin area against the dorsum of the sacrum, 30 cc of 1.5 per cent solution is slowly injected.

11 Ointment is now generously spread around collar of needle.

*Indications that the Solution Is Being Injected Into the Peridural Space of the Sacral Canal*—(a) The patients usually experience a sense of fullness progressing to an uncomfortable sensation in one or both legs as the solution circumscribes the perineural components of the sciatic nerves. This sensation can be minimized by slower injections.

(b) There will be a progressive analgesia in the areas supplied by the coccygeal, hemorrhoidal, perineal, pudendal, ilioinguinal and iliohypogastric nerve. Analgesia should be complete in twenty minutes.

(c) There is relief of abdominal uterine cramps within five to fifteen minutes after injection.

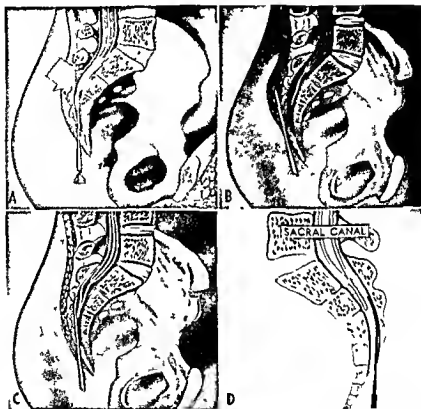


Fig 496—A, Low lying dural sac B, Episacral injection, C, Subperiosteal injection D, Correct peridural injection (After Lull, Clifford B and Hingson Robert A. Control of Pain in Childbirth, J. B. Lippincott Co.)

(d) Pronounced vasodilatation, cessation of sweating, and increase in temperature of the skin of the feet will ensue within five to fifteen minutes after injection. Clinical experience indicates that the great toe and the ball of the foot are the first part of the feet to develop vasomotor block. The heels are usually the last part of the feet to become pink, warm and dry. This phenomenon is often noticed on one side several minutes before it occurs on the other.

*Indications that the Solution Is Being Injected Outside the Sacral Canal*—(a) The injection fails to relieve pain within thirty minutes. (b) An 'injection tumor' appears superficial to the dorsum of the sacrum.

**Supplementary Injections**—The supplementary injection will depend on the rate of metabolism of the drug by the individual patient. In our experience 20 cc. of additional solution injected every thirty to sixty minutes is sufficient to keep the parturient comfortable for the entire course of labor. We have continued our supplementary injections for a maximum of thirty hours and for an average of seven hours.

In a few instances we have had to increase the maintenance dose to 30 cc. Rarely, in exceptionally large individuals, this dose has been increased to 40 cc. before adequate relief of pain was obtained. We have noted further that when the level of analgesia was permitted to drop below the level of thoracic nerve roots XI and XII with a subsequent return of contraction pains, often a larger dosage than the maintenance dose of 20 cc. will be necessary to bring about complete relief. As long as the level of analgesia on both sides extends to the umbilicus the patient is definitely comfortable. Obviously when the level ascends to the xiphoid or nipple line, no further injections are needed until the pharmacologic effect of the last dose is permitted to wear off. In a few individuals we have seen a single dose provide complete comfort for a period of two hours. The indication for a repeat dose is a descending level of analgesia below the umbilicus.

We have begun to use the nylon catheter needle which combines the advantages of both the needle and the catheter, and thus reduces or eliminates trauma within the sacral canal.

We consider this method of analgesia to be a specialized procedure which requires special training to obtain uniform, satisfactory results. In our clinics we have found that the specially trained obstetric nurse anesthetists are competent to manage the supplementary injections after the needle has been properly inserted by the physician. Medical supervision of the patients and management by the obstetric nurse anesthetists are recommended at all times. We found that one nurse anesthetist with one student nurse in attendance could adequately supervise the labors of four patients at once.

Recently I have written in the *British Medical Journal* the following

Investigators throughout the world have modified and extended this method of analgesia into other fields. Invariably it has been abandoned from time to time for the following reasons:

1. Anatomic variations in the region of the sacrum.
2. Technical difficulties concerned with the administration of anesthetic solutions into this area.
3. The prolonged induction time of 20 to 30 minutes necessary to provide total sensory nerve block.
4. Systemic complications which have resulted from misapplication of the technic through occult subarachnoid injection, intravascular injection either through vein, capillary plexus or direct bone marrow injection into the cancellous corpora of the sacrum.
5. Lack of knowledge concerning the anatomy and volumetrics of the



peridural space which produces a wide range of dosage in even a few cases

We are aware of all these problems. We have altered the technique in a manner that continuous caudal analgesia through controlled, intermittent injection provides the patient with greater safety and permits the operator to eliminate technical difficulties and to make adjustment for anatomic variations. There can be no question concerning the fact that properly managed continuous caudal analgesia provides the parturient with greater pain relief during both labor and delivery than has been achieved by any other method. This fact has been substantiated by the observations in more than 100 American clinics who have contributed 166 scientific papers to the medical literature.

In our own clinic at the Philadelphia Lying In Hospital we have managed more than 3000 labors and deliveries with this technique in the past two and one half years. Major James M. Stever at Fort Sam Houston, Texas in the United States Army Brooke General Hospital has managed more than 24 such cases. Dr. Francis R. Irving, Professor of Clinical Obstetrics at Syracuse University, Syracuse, New York has managed 2000 such cases. Dr. R. C. Nicodemus of the Geisinger Memorial Hospital, Danville, Pennsylvania has managed more than 1000. Major Franklin D. Sinclair in the United States Army Kennedy General Hospital, Memphis, Tennessee has managed 850. Dr. William Levine, Beth El Hospital, Brooklyn, New York has managed more than 1800. Dr. W. Royce Hodges of Cumberland, Maryland has managed 856. Dr. Waldo B. Edwards, United States Marine Hospital, Staten Island, New York, has managed 900 cases. Dr. Norman H. Miller of the University Hospital, Ann Arbor, Michigan has managed 650 cases. Dr. Julian Mine, Philadelphia, Pennsylvania more than 1000 cases. Dr. R. W. Alles, Detroit, Michigan has managed 400 cases. Drs. Ellis and Sheffery of Washington, D. C. have managed 500 cases. The group at Stanford University in San Francisco, California have managed more than 1000 cases.

From the combined reports in the American literature we find that more than 100,000 women in North America and an impressive number in South America and Central America have been managed by this technique which is not too difficult for the average physician to master. All the reports from these clinics indicate a reduced maternal and fetal mortality and morbidity, more complete relief of pain and a uniformly decreased third stage blood loss than is seen in any general anesthetic management.

Among our own 3000 cases satisfactory relief was obtained during active labor and delivery in 92 per cent of the cases. The patients were managed by physicians numbering more than 500 and representing forty-four American states and twenty-nine foreign countries, who completed our postgraduate medical instruction. In this series of cases only three maternal deaths occurred—all several hours and several days after management under continuous caudal analgesia. These deaths resulted from the following causes: (1) intraventricular hemorrhage in an elderly primipara, (2) unexplained hyperpyrexia in a toxemic multipara with inadequately treated syphilis and (3) an exacerbation of an acute *Streptococcus viridans* mitral endocarditis. The only neurological complication was perineal nerve footdrop in two infants. One completely recovered after six months, the other, after fourteen weeks has recovered 60 per cent. We have not found an increased

number of catheterizations following delivery when our recommended methods of management have been carried out.

Major James M. Siever of the Brooke General Hospital, Fort Sam Houston, Texas, has summarized for me, as follows, his first 2300 deliveries with the technic which will be described subsequently:

SUMMARY OF THE USE OF CONTINUOUS CAUDAL ANALGESIA AT FORT SAM HOUSTON, TEXAS, FROM JUNE, 1943 TO JANUARY, 1945

Total deliveries	2,300
Multiparous	496
Primiparous	1,904
Posteriors . .	238
Manually rotated	91
Forceps rotated	147
Breech presentation	80
Multiple pregnancy	22
Posterior face	1
Procaine .	1,800
Metycaine	500
Fetal deaths (2.6% gross)	61
Premature (less than 30 weeks)	26
Stillborn (before admission to hospital)	25
Monster . . . .	7
Cerebral hemorrhage	3
Procaine—251 cases had to be catheterized once	
Metycaine—100 cases	
Spinal canal hit six times (each time recognized before solution given)	

**Indwelling Ureteral Catheter Technic for Continuous Drip Caudal Analgesia** (by Major James M. Siever, Fort Sam Houston, Texas).—1. The patient is placed on her right side in a modified Sims' position and close to the side of the bed.

2. The lumbosacral region is scrubbed with soap and water followed by alcohol and ether. Tincture of merthiolate then is applied to the region and sterile drapes are put in place.

3. Procaine hydrochloride 1.5 per cent solution is prepared by adding the contents of two 5 cc. ampules of 20 per cent procaine hydrochloride to 125 cc. of sterile isotonic solution of sodium chloride.

4. A skin wheal is raised over the sacrococcygeal ligament. A 15 gauge needle is passed through the skin wheal and is advanced through the sacrococcygeal ligament. After the tip of the needle comes in contact with bone on the anterior border of the caudal canal, the needle is rotated 90 degrees to bring its bevel against the bone. The hub is depressed and the needle is then advanced about 1 inch (2.5 cm.). A glass syringe containing 25 cc. of the anesthetic solution is attached to the needle and 1 or 2 cc. of the anesthetic solution is injected to clear the needle of any obstruction. The plunger is withdrawn gently in order to make sure that the tip of the needle is not

lying within the lumen of a blood vessel or within the subarachnoid space Twenty five cubic centimeters of the anesthetic solution is then injected slowly into the caudal canal

5 As soon as the initial dose has been injected the syringe is detached from the needle and a No 4 French nylon ureteral catheter which has been sterilized in an autoclave is passed through the needle and is advanced until the tip of the catheter is approximately  $1\frac{1}{2}$  inches (3.8 cm) above the sacral hiatus, the needle is then removed over the catheter

6 The catheter is padded with sterile gauze at the point of entrance into the skin and brought over the patient's back to her flank and the entire region is sealed with waterproof adhesive tape to prevent soiling from the perineum

7 The patient may now be turned on her back and made comfortable in any position that she desires

8 A continuous drip is attached to the catheter and is set to deliver 20 cc per hour If at the end of an hour the level of anesthesia is too high or too low the drip may be either increased or decreased proportionately

The gravity apparatus used at this clinic is a modification of that used by Block and Rotstein A glass cylinder graduated in cubic centimeters is interposed between the drip and the main reservoir containing the anesthetic solution. This cylinder receives the solution from the main reservoir and subsequently delivers it to the drip At hourly intervals 15 to 25 cc of the solution depending on the level of the patient's anesthesia is turned into the cylinder During the succeeding

method A definite amount of solution may be given at required intervals and yet may be given slowly by gravity

We prefer the use of the continuous drip for the following reasons

1 Placement of the catheter in the soft tissue overlying the sacrum is easily detected since pressure over the sacrum stops the flow of the anesthetic agent through the drip apparatus

2 Chance of infection is decreased, owing to a completely closed system

3 It is the most simple type of apparatus

4 The level of anesthesia is relatively constant With other methods the level of anesthesia is constantly rising and falling

5 There are reduced volume of agent and pressure in the caudal canal which together with the constant level of anesthesia we believe accounts for the decreased incidence of nausea and vomiting obtained with this method

6 The total amount of anesthetic used is less In our 600 cases in which the drip method was used the amount of solution used per hour to keep the level of anesthesia at the umbilicus was 25 per cent less than in our previous series

7 Our modification makes it possible to obtain all the advantages of both the multiple injection and the gravity method

**Continuous Spinal Anesthesia and Analgesia**—Our experience following a study of the basic postulates of Cosgrove has led us to adopt the following procedures for terminal labor and obstetric delivery

1 Preanesthetic medication should consist of no more than  $1\frac{1}{2}$  grains of one of the barbiturates plus  $\frac{1}{150}$  grain of scopolamine It should be emphasized that large sedative doses of barbiturates which offer a protection to the patient receiving local and caudal analgesia are not the antidote in spinal anesthesia Recent evidence indicates that the barbiturates in spinal anesthesia may even have a depressing, rather than a protective, effect

2 The patient's blood pressure should be checked, and should the systolic tension be lower than 90 mm of mercury, spinal anesthesia is contraindicated

3 Debilitated and cachectic patients should be given 100 per cent oxygen inhalation therapy for fifteen to twenty minutes in order to saturate the tissues and the blood stream before spinal anesthesia is begun

4 The patient should lie comfortably on her side in a position of as much total flexion as her pendulous abdomen will permit An intracutaneous wheal should be raised between the first and second or the second and third lumbar spines with a small hypodermic needle A 2 inch fascia needle should be slowly advanced through muscle and between the ligaments of the spinous processes of the designated segments for deeper infiltration of 1 or 2 cc of 1 per cent procaine or metycaine Except in the hypertensive or preeclamptic patient, 25 mg ( $\frac{3}{8}$  grain) or 50 mg ( $\frac{3}{4}$  grain) of ephedrine hydrochloride as a prophylaxis against a too rapidly falling blood pressure should be administered

5 A 19 or 20 gauge spinal needle is advanced through the intraspinous ligament, the epidural space, the dura mater, the subdural space and the arachnoid The advancing needle will often pass through two resistant obstructions which can be felt by the operator as the needle penetrates the intraspinous ligament and the dura mater

6 When a free flow of spinal fluid has been obtained, 25 to 50 mg of 2 per cent procaine or 15 to 30 mg of 15 per cent metycaine should be slowly injected

7 An assistant should determine by rectal examination whether the patient is in a deliverable state If a rim of the cervix still remains, the patient should be left on her side with the spinal needle still in place until the cervix has disappeared and the head has descended to the optimum level Should this require longer than thirty minutes to an hour and a half, a second injection and even a third of 40 to 50 mg may be administered with relative safety to the patient.

The simple precaution of leaving the patient on her side with the

level of the spinal needle free in the subarachnoid space adds a controllable feature to spinal anesthesia which makes it one of the safest methods for operative delivery that we have at our disposal. Its mechanism of safety is the fact that any amount of the injected drug can be withdrawn at will in the presence of profound pharmacologic effect. Its mechanism of efficiency is the fact that subsequent doses of the drug can be administered in the refractory case to provide total relief of pain and optimum relaxation of the cervix and perineal floor. There is no method of pain relief in medicine in which the possibility of toxic pharmacologic action is so small. This is the one method which, when properly administered, absolutely protects the baby from transplacental intoxication.

The techniques of pudendal block, presacral block, paravertebral block and peridural lumbar analgesia are old and established procedures. These techniques are described in the "Control of Pain in Childbirth" by Lull and Hingson.

#### TECHNIQUES FOR THE CONTROL OF FEAR AND TENSION

Grantly Dick Read in his book, "Childbirth Without Fear," has stated

The great intensifier of stimulus interpretation is fear. This emotion, like pain, is protective and produces through the sympathetic nervous system a state of tension within the body. Thus we have the three great evils—Pain, Fear, and Tension. It is this syndrome which is responsible for the pain of labor. My contention is that the pain of labor is the result of an assault upon a primitive function which is intended to be painless. The attack is made by forces against which no protective apparatus has been developed, because the

appears however, that a more rational method of approach to this problem would be to discover the most vulnerable point at which to make a counter attack, not only to resist this dangerous invader which we call fear, but also to set up an efficient protective mechanism so that the primitive function of painless childbirth may be recognized by civilized women for all time as both natural and normal.

The perfect painless labor will be attained, but not by the administration of drugs and agents to destroy consciousness. By careful and patient investigation of the phenomena of labor, observations will be made from different aspects. Chemical, neurological, psychological, mechanical, electrical and even metaphysical facets to this physiological gem will flash some new message to those who care to look, and in time these varied observations will be correlated and sifted until the truth of natural painless labor is obvious to all.

Lull and Hingson have written in their "Control of Pain in Childbirth"

Pain can be brought to a frightful nearness through the telescope of fear. Fear can be greatly accentuated and magnified through the microscope of

pain. These two processes are pathologic psychic germs which when present in an uncontrolled form may periscope into the sensorium an irreversible emotional trauma. The control of pain is achieved by two methods: (1) the anatomic approach, i.e. by blocking pain impulses at their source as in local spinal and regional anesthesia and caudal analgesia; (2) the encephalic approach, i.e. by obliterating pain at its site of interpretation in the central nervous system through various forms of general intravenous and rectal anesthesia. Some measure of control is afforded by obtunding the memory of pain through the use of drugs which produce amnesia or forgetfulness. The control of fear is sometimes the more difficult of the two and can be managed by the establishment of the patient's confidence in her physician and by the maintenance of comfort in her surroundings. The patient in whom fear is completely controlled is the ideal one for the use of the anatomic approach. The one in whom fear is uncontrolled can be relieved usually more satisfactorily by one of the forms of general anesthesia or amnesia.

There is certainly no field of medicine where confidence in her attending physician is of as much importance as it is in the practice of obstetrics. Therefore any reassurance that can be given a pregnant woman should be given as frequently as possible during the pregnancy. One of the pleasures of the practice of obstetrics is the fact that usually everyone concerned is made happy by the advent of the new offspring. This pleasure can be greatly reduced if the patient goes through pregnancy and labor fearful of the outcome for both herself and her child. We believe it wise to tell a pregnant woman just what occurs with the onset of labor and what she should expect when labor has been fully enforced. Many women appreciate the fact that their physician regards them as sufficiently intelligent to understand the processes of nature. As a result of the careful mental build up during pregnancy the patient arrives in the labor room in a state of mind which makes her nervous system easily susceptible to whatever method of analgesia is employed. It has been our experience that women who are frightened or apprehensive do not respond to many of the various types of analgesia used today. For example an individual in such a state when given the barbiturates or various combinations of drugs very frequently will not become amnesic and if she does will have a tendency to become excited.

We have found that patients of intelligence react more favorably under all forms of analgesic, amnesic and anesthetic agents whereas the illiterate or those of subnormal mentality present our greatest problems in controlling pain. This class are particularly unsuited for delivery while in possession of their mental faculties.

There are certain recommendations that I would make to hospitals with postwar plans for reconstruction of the labor floor:

1. The noisy labor room or rooms in which patients are managed under deep sedation or under amnesic analgesia should be physically separated from the quiet labor rooms in which patients have total elimination of their pain through the method of regional analgesia of the anatomic approach. Air conditioning and soundproofing would solve this problem. Should air conditioning be instituted, it would be a factor of great importance to construct an inlet for pure oxygen in order that the oxygen concentration of a labor room could be increased under regulated control in much the same manner as oxygen is now released in some of our better theaters. This extra benefit of oxygen would prove of great value to the anemic patient, the patient

with cardiac or respiratory disease and the patient with a hypotension of fatigue or with a hypertension from the pharmacologic action of the analgesic drug. The beneficial effect on the mother would be reflected in an ameliorated condition of the baby. This would be particularly true in the case of the premature infant.

2. The patients who are managed with methods totally eliminating pain by means of continuous caudal analgesia or continuous spinal anesthesia must have provided for them facilities for mental recreation. The following are suggested:

- (a) Attractive interior decorating of the labor room with indirect lighting and controlled reception of sunlight
- (b) Carefully chosen restful paintings of flowers, landscape, or water scenes could be artfully placed around the walls
- (c) A small attractive bedside library supplied with recent periodicals and short stories
- (d) A bedside radio
- (e) A small hostess table on which the patient and nurse could enjoy together tea, cocoa, or milk
- (f) A carefully selected attractive bed with hard sponge rubber mattress or a comfortable mattress supported in the center with fracture boards to prevent a central sagging of the mattress when the patient is lying on her side in the relaxed state of caudal analgesia or spinal anesthesia. If these precautions are not taken, there are some cases, especially in multiparas with pendulous abdomens, in which the advancing presenting part of the baby will become dislocated from the pelvis. In cases in which attention to this detail is not possible, the patients should labor on their backs and with abdominal binders in indicated cases.
- (g) An attractive wall mirror conveniently located to the patient that she might keep herself physically tidy and thus boost her own morale in maintaining her self respect.
- (h) Since many women in labor, because of endocrine disturbances, develop a nasal congestion, benzedrine inhalers or ephedrine nose drops should be provided as part of the routine management.

We have found it useful to provide patients in control of their mental faculties in labor with a bedside bell with which they might call for assistance upon the early return of pain or when they might need something necessary for their own comfort. We have found in some instances, that a psychological advantage may be achieved by permitting two patients to share the conversation and thus relieving this ordeal.

Integration of the parturient into the external environment. In the Marine Hospital in New York, we permitted women who seemed to have time on their hands to make sponges and cotton balls for the other patients while they were in labor.

If a patient is in the hospital before the onset of labor, she should hear no conversation concerning other patients and should be tactfully reassured concerning her own welfare. The pains associated with

the advent of labor can usually be classified as annoying rather than painful. Many women in the early stages of labor can be made happy by reassurance from the attending physician that the discomfort is really trifling, together with the thought that something will be given to relieve the pain as labor progresses. This will oftentimes allow the labor to become well established before any form of pain relief is instituted.

It is true that a large number of women in the past had very easy labors. This is also true of the present. All of us who are interested in either obstetrics or in pain relief during labor have tried to learn why the modern American girl does not stand pain as her forebears did. This is still a debatable question and one in which probably many things are involved.

Some writers believe that it makes for better motherhood if a woman is given no pain relief. Why the agonizing pains of labor should increase any of her natural instincts for motherhood has never been quite clear in our minds. The failure of medicine men and midwives to deal with this *poena magna* adequately, if at all, compelled women in labor to seek the services of physicians. The cries of women in travail called the art of obstetrics into being. The obstetrician who overlooks this obligation is causing a retrogression of obstetrics to midwifery. It has always been the duty of a physician to relieve pain. Since the pains of childbirth are probably as severe as any to which the human structure is subjected, it seems reasonable that if relatively safe methods of relief, without injury to either mother or child, are available, they should be administered.

We have seen many patients who have refused any form of analgesia and anesthesia because they were *curious to know exactly what* happens during the process of parturition. Usually these patients, when they return for their second confinement, have learned enough by the first experience and will not object to some form of pain relief.

The advent of continuous caudal analgesia has opened up a new field in the psychology of childbirth. One of the greatest psychological factors, as far as the mother is concerned, is to hear her baby's first cry. This has been so clearly demonstrated since the use of continuous caudal analgesia that we believe it has impressed everyone who has had any experience in its use. This technic has returned to womanhood the heritage which she had to sacrifice through the use of various forms of anesthesia and amnesia.

The patient of high intelligence who has absolute confidence in her obstetrician and who goes through labor relieved of pain but conscious of her surroundings and what is being done for her has in her mind an indelible impression of what is actually the concept of modern obstetrics. In the management of a patient who is conscious, much can be and should be done to give her mental tranquility without



fear of the outcome of her labor This is accomplished by a cheerful atmosphere in the labor room, which should be furnished much like the patient's own comfortable room at home The conversation should be along lines that have nothing to do with her present ordeal Her interest in reading light literature should be aroused Her thoughts can be taken away from her present environment by the judicious use of the radio, as for example, one patient became so engrossed in listening to a football game that she was reluctant to leave the labor room for the delivery of her baby, another enjoyed a full program of the Metropolitan Opera during her labor These two incidents indicate that a suitable type of entertainment for the patient is not incompatible with good scientific management of the case A favorite form of occupation of our patients under caudal is a soft drink or tea party The hot fluids, glucose, caffeine, and relaxation afforded by this repast are welcomed by both nurses and patients When a patient is given continuous caudal analgesia, the psychology of the patient and attendants in the labor room is entirely different from the management of a patient under the sleep producing methods

If the labor is managed by the use of amnesic or sedative drugs, the following conditions should be instituted (1) absolute quiet, (2) a partially darkened room conducive to sleep and rest Particular emphasis should be placed on the conversation between those in attendance, because although the patient may seem to be entirely unconscious, oftentimes under the influence of these drugs statements are confused and are remembered after the drugs have been eliminated Instances have been cited where patients have been emotionally upset following their labor because they thought statements detrimental to themselves or their personality were made while they were under the influence of the drugs

In obstetrics, as in surgery, there has been a resurgence of applications of methods of regional nerve block for pain relief to eliminate, wherever possible, profound sedation and general anesthesia during labor and delivery In the obstetrics of the future, the baby can be and must be spared transplacental narcotization Wherever hospital facilities and trained personnel are available, parturient women can be, and will be, spared much of the anguish of fear and pain in child birth

As I have observed many thousands of labors throughout the United States, this word of warning should be imparted, both to parturient women and to overzealous obstetricians who desire to relieve the first pain—"dolor primum" At least 5 to 10 per cent of women in preliminary labor develop a rhythm of contraction which, for various reasons, often subsides into a false start The emotions play a great part in these false labors For example, we had one multiparous patient who came into the hospital with five-minute contractions and a bloody show After three hours of this labor she was informed by

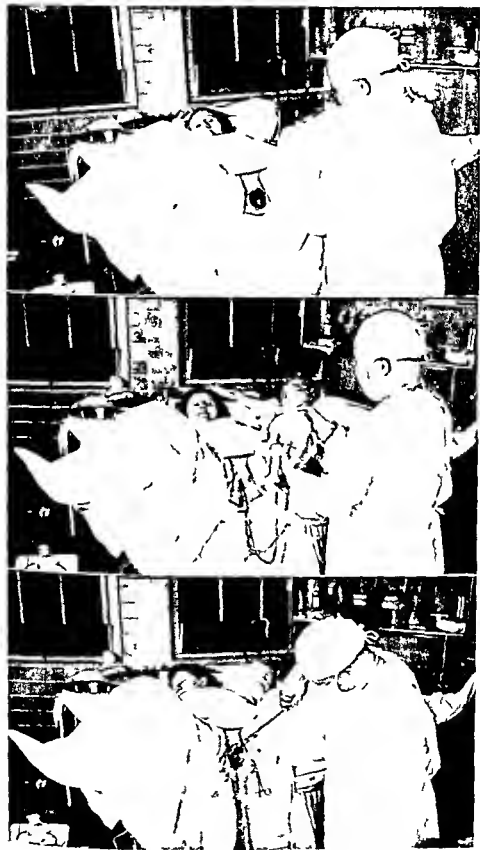


Fig 497—*Top*, Crowning against relaxed perineum *Center*, Spontaneous delivery and instantaneous infant respiration *Bottom*, Accelerated third stage with minimal blood loss The patient was managed with continuous caudal analgesia

her husband that her mother had died. The contractions stopped for a twenty eight hour period before terminating in a five hour productive labor. Likewise, many patients who began labor at home with three to five minute contractions arrive at the hospital emotionally excited and received a surgical preparation, an enema and have several rectal examinations by an unfamiliar intern or resident. Sometimes these patients are prematurely rushed to the labor room where they are frightened by the uncontrolled screams of a patient in the



Fig 498—Total collected and measured blood loss (170 cc) with placentae following deliveries of four consecutive patients with continuous caudal analgesia

second stage of labor. Under such circumstances it is not an infrequent occurrence for these women to have an emotional arrest of uterine contractions for several hours to more than three days. One of our patients came to the hospital three times in one week in false labor, her productive labor ensued ten days later. Patients as well as physicians should be made to understand these possibilities. Parturients can be provided total relief of the distressing pains of labor, but they should be protected from the profound narcotization of some technics

during the preliminary or prodromal stage. They and their babies should be protected. Too many patients have been sedated for the cramps initiated by the expulsion of an enema.

The exploitation of the words "painless childbirth" by an uninformed lay press should be condemned by the medical profession with the emphatic substitution of the term and principles the *control of pain in childbirth*.

Pain relief in obstetrics through pharmacologic application of drugs aside from accentuating the complications of arrested labor and multiplying the instances of operative delivery, greatly increases the most common cause of maternal death and delayed convalescence, namely hemorrhage. The uterus of a patient who has undergone hours of narcotization in labor and a period of deep anesthesia with difficult operative delivery cannot be expected to maintain a contractile tone any more than could the same be expected of the patient's biceps brachiae or quadriceps femorae muscles. In my opinion one of the primary causes of the so called physiological obstetrical hemorrhage exceeding a 200 cc blood loss is general anesthesia administered to a depth of the second plane in the surgical stage. The judicious use of methods of regional nerve block for pain relief in obstetrics aside from protecting the baby, will bring about an emancipation of the mothers in travail through the salvage of blood and the control of fear and pain.

## CONTINUOUS SPINAL AND CONTINUOUS CAUDAL ANALGESIA IN CESAREAN SECTION

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THE administration of regional or local analgesics for operative procedures has gained increasing prominence in the past few years and with improvement in technic and drugs, their use will continue and, I believe to a large measure supplant the older types of general anesthetic agents now employed. The pioneer achievements of Pitkin, Lemmon, Hingson and Edwards and Cosgrave have built a foundation which offers increasing advantages in obstetrics.

The ill effects of various drugs and inhalation anesthesia on the unborn child have long been recognized. The marked narcosis of babies delivered by these methods has been one of the highest causes of fetal mortality. Because of the dangers to the mother associated with one dose spinal anesthesia for cesarean section this method was discontinued in all but a few clinics and for some years a local anesthetic agent has been looked upon as the safest for mother and child. However not every patient is suitable for this type of anesthesia and not all surgeons have the necessary tranquility to use it.

Since the introduction of continuous caudal analgesia over ten thousand patients have been safely delivered vaginally and with the minimum of complications and mortality. Likewise reports of safe deliverance have been made with continuous spinal anesthesia. Early in the use of these analgesics cesarean section was also performed and it is the purpose of this report to show the indications, technic and advantages of each for cesarean operation.

### CONTINUOUS SPINAL ANALGESIA IN CESAREAN SECTION

In 1939 Lemmon conceived the idea of continuous spinal analgesia for general surgery. Since that time its safety has been well demonstrated. The application of this method to cesarean operations followed since it offered an ideal method of safety and controllability which is so necessary for this operation. In 1942 Heard of Toronto emphasized its importance to the baby by his statement "He who denies the baby the safety of spinal anesthesia must be prepared to accept the responsibility of protecting the baby from ether."

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**Advantages**—1 The safety of continuous spinal analgesia lies mainly in the administration of smaller initial doses instead of the previous one injection method. This is because the most dangerous period of spinal analgesia is within the first thirty minutes after injection. With the giving of a small initial dosage of the drug any untoward toxic symptoms will be minimal, and with the needle in the subarachnoid space, most of the drug can be rapidly withdrawn by removing several cubic centimeters of cerebrospinal fluid.

2 The controllability of continuous spinal analgesia is of paramount importance in cesarean section. A very small dose of the drug is given to reach the desired level just above the operative field. Usually this will suffice for the operation. Additional doses may be given if the operation requires longer. Thus a very minimum of the drug can be used and be at all times well controlled. If the level reaches too high or the blood pressure falls below a safe level, most of the drug can be withdrawn by aspiration.

3 The ease of administration is noteworthy. As the technic consists essentially in making and maintaining a spinal puncture, even the occasional operator can perform it easily. A spinal puncture is one of the easiest procedures in medicine, and with the addition of a few technical details the analgesia is easily given.

4 The speed of the procedure likewise offers certain advantages. Frequently a rapid cesarean section is imperative, and with the short time required for a spinal puncture plus administration of the drug, and its rapid action in producing analgesia, loss of blood to the mother and fetal mortality can be markedly lessened.

5. The decrease in postoperative complications following its use also makes it ideal. The reduction in postoperative nausea and vomiting, with less abdominal distention than with inhalation agents, is marked. Usually patients having continuous spinal analgesia for cesarean can be fed the same day of operation, which eliminates many of the abdominal complaints. Urinary retention is no greater and phlebitis is probably less frequent, as also are pulmonary complications.

6 Excellent contraction of the uterine musculature, with minimal blood loss, is outstanding. Few oxytocics are required following delivery of the baby.

7. The absence of narcosis to the baby offers one of the greatest advantages of this method. There is no need for resuscitation of the baby, as respiration is initiated usually before the baby is completely extracted from the uterus, and he cries immediately. This is particularly valuable in premature infants born by cesarean section.

8 Excellent relaxation of the abdominal wall is an outstanding characteristic and enables the operator to perform his task with facility and dispatch. This is essential in Waters' or extraperitoneal sections where relaxation is imperative.

9 Likewise, the anesthetic causes no disturbance of previously ex-

mg) can be added if the level is not sufficiently high, but this is seldom necessary.

The blood pressure, pulse and respiration are carefully taken every five minutes during the operation. The systolic pressure seldom drops more than 10 to 20 mm of mercury, and many cases have less than 10 mm fall. If the systolic level reaches 90 mm or less  $\frac{3}{4}$  grain ephedrine hydrochloride can be given hypodermically or glucose saline solution intravenously. Plasma should be available. In cases which show a profound fall in blood pressure a vasopressor drug can be given intravenously.

If the analgesic begins to wear off and the patient complains of discomfort, additional doses of procaine can be given, usually in doses of 0.5 to 1 cc (12.5 to 25 mg).

After the baby is extracted  $\frac{1}{4}$  grain of morphine should be given hypodermically which will reach its maximum effect after the anesthetic has been removed. Following delivery of the placenta an oxytocic preparation (usually ergot) is given intramuscularly as a routine procedure. Following completion of the operation the remaining drug is partially removed by aspirating 1 to 2 cc of fluid, and the needle is withdrawn.

After removal from the operating room the patient is returned to her room and placed flat in bed. Fluids and soft food can be given the same day.

**Indications and Contraindications**—Continuous spinal analgesia may be used in all types of cesarean section. The condition of the patient however must be good. In the presence of severe hemorrhage from placenta praevia or abruptio placentae where the general condition of the patient is poor it would be unwise to use continuous spinal analgesia. In cases of prolonged labor in which cesarean operation becomes necessary supportive measures must be instituted before analgesia is given.

**Agents**—Either procaine hydrochloride or metocaine (1.5 per cent in Ringer's solution) may be used as the anesthetic agent. Both possess low toxicologic drug reaction and give no depression of vital centers. They are easily obtainable and require small amounts. Their duration of analgesia is approximately the same and neither causes any postoperative complications.

#### CONTINUOUS CAUDAL ANALGESIA IN CESAREAN SECTION

Since the introduction of continuous caudal analgesia in obstetrics by Hingson and Edwards it has proved its merit in cesarean section as well as vaginal deliveries. Like continuous spinal analgesia it is superior to inhalation anesthetics and its benefits are practically the same.

**Advantages**—1 The safety factor of continuous caudal analgesia in cesarean section lies in its careful administration by a competent trained individual who employs the same precautions used in continu-

ous caudal analgesia for vaginal deliveries. By careful establishment of the proper analgesic level the blood pressure remains within normal limits.

2 The controllability of caudal analgesia can be regulated too, by the continuous or fractional method. Only sufficient drug to produce the required level is given and additional doses added if the operation proceeds unexpectedly long. In this way only the minimal amount of drug is required, and its low toxicity is held to a minimum.

3 The recovery of patients following continuous caudal analgesia in cesarean section is very satisfactory and the amount of postoperative discomfort is minimal. There is little, if any, nausea or vomiting following delivery and distention is much less than with inhalation methods. These patients can be fed the same day after operation and their convalescence is accelerated. The incidence of urinary retention is the same as for continuous caudal analgesia in vaginal deliveries and is no greater than with inhalation anesthetics.

4 Blood loss during and following cesarean section under continuous caudal is minimal and is seldom over 100 cc. This is a definite decrease from sections under inhalation methods. The uterus shows remarkable contractile powers as soon as the baby is extracted and oxytocics are seldom used.

5 The absence of narcosis to the baby is one of the greatest advantages of this method. The baby requires no resuscitation and cries immediately when extracted from the uterus. The color of the baby is good and it shows no impairment of oxygenation.

6 Continuous caudal analgesia is particularly valuable in patients who have previous existing disease, such as pulmonary complications, heart disease or diabetes, as it causes no disturbance of these conditions whereas inhalation anesthetics frequently cause profound changes.

**Technic**—1 The patient is prepared first by mental reassurance, carefully explaining the method and procedure. This allays any fear. At the same time the husband is informed that at least a half hour must elapse before the operation can be started, so that he will not expect her to return to her bed in the usual short period of time.

2 Adequate fluid intake is maintained preceding the operation.

3 The patient is given  $1\frac{1}{2}$  grams (0.1 gm) of a barbiturate the previous night and again one hour before operation.

4 With the patient lying in the modified lateral Sims' position the sacral area is thoroughly cleansed with green soap and ether and two coats of antiseptic tincture. The sacral hiatus is then identified, the skin wheal is raised and the caudal needle carefully inserted through the sacrococcygeal ligament.

5 One and five tenths per cent metycaine in Ringer's solution is used and 50 mg. of ephedrine hydrochloride is given intramuscularly at the time of the first injection.



6 An initial test dose of 8 cc is administered with careful check by aspiration to prove the needle is not within the subarachnoid space or a blood vessel

7 A supplementary dose of 40 to 60 cc, depending upon the size of the patient, is then given. The patient is then placed on her back and the level of analgesia tested in twenty minutes

8 If the level has not ascended above the umbilicus on both sides, a supplementary or third injection of 20 to 30 cc, according to the need of the patient, is administered

9 When the level of analgesia is complete on both sides to the height of the eighth dorsal segment, the operation may begin. A cure

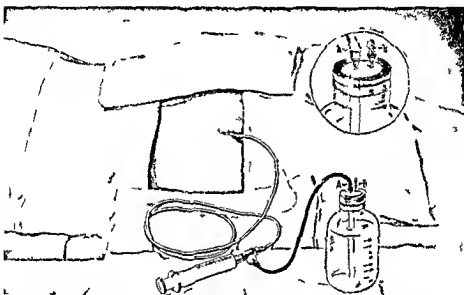


Fig 501 Apparatus for continuous caudal analgesia (Courtesy of Eli Lilly Co)

ful check of blood pressure and pulse is maintained throughout and any excessive blood pressure drop treated promptly with supportive measures, such as ephedrine, or glucose saline solution, or plasma. Also the elevation of the patient's legs will restore a fall in blood pressure by gravity autotransfusion. During this time 100 per cent oxygen should be administered by inhalation.

10 The time required for the analgesic effect varies. It may be from twenty to eighty minutes, but usually an average of thirty five minutes from the first injection of metycaine.

11 At the conclusion of the operation the patient is given  $\frac{1}{4}$  grain of morphine sulfate hypodermically. This eases postoperative and incisional pain.

**Indications and Contraindications**—Continuous caudal analgesia is indicated for classical cesarean sections or low cervical sections. It is a

valuable agent in cardiac disease or metabolic diseases and no change in the regimen of the patient with complications is necessary. It is used particularly in patients who may have had an initial test of labor under caudal and the need arises for section, as the level is already established and operation can be performed quickly. Also in severe toxemias in which cesarean section is required, the symptoms and blood pressure elevation are alleviated during and following operation. In patients who have had previous existing thrombophlebitis it offers a safe anesthetic where operation is required.



Fig 502.—Cesarean section under continuous caudal analgesia. Note the immediate cry of the baby. (From Lull Clifford B and Hingson Robert A. *Control of Pain in Childbirth*. J. B. Lippincott Co.)

The contraindications are listed as follows: (1) Gross deformities of the spine, particularly the sacrum; (2) Tumors which narrow the spinal canal; (3) Local infection around the sacral hiatus; (4) History of sensitivity to the analgesic agent; (5) Profound anemia, or shock; (6) Placenta praevia, because of its effect of relaxing the cervix and increasing bleeding; (7) Hysterical patients.

#### SUMMARY AND COMMENT

From the standpoint of the pharmacological effect upon the baby in utero, there is no method of relief of pain for cesarean section which

provides such safety, through absence of toxicologic drug reaction and depression, as spinal or caudal analgesia. Under the control of the continuous or fractional method spinal analgesia provides the additional factor heretofore not achieved in anesthesiology, namely, the method of giving very small doses initially—the necessary minimum for the operation—plus the mechanism of instantaneous recovery of a large amount of the excess quantities of the drug by aspiration of the spinal fluid containing the drug. Its safety, controllability, speed and ease of administration provide an outstanding analgesia in the obstetric armamentarium.

Continuous caudal analgesia likewise offers the same safety to the child and mother with careful technic. It requires a specially trained and competent anesthesiologist to administer and supervise. Certain obstetric complications are best treated by cesarean section under this method.

# ROENTGENOLOGICAL VISUALIZATION OF THE SACRAL HIATUS DURING LATE PREGNANCY

PAUL A. BISHOP, MD \*

VARIATIONS of size and shape of the sacral hiatus are easily recorded on roentgenograms of the nonpregnant patient. The hiatus is almost invariably shown in conventional anteroposterior views of the pelvis. However, in the pregnant patient the shadow of the fetal skeleton overlies the area and obliterates the shadow of the hiatus.

By a slight variation of the technic of the "subpubic angle" film described by Moloy and Swenson,<sup>†</sup> the lower part of the sacrum is projected below the fetus with very satisfactory visualization of the hiatus.

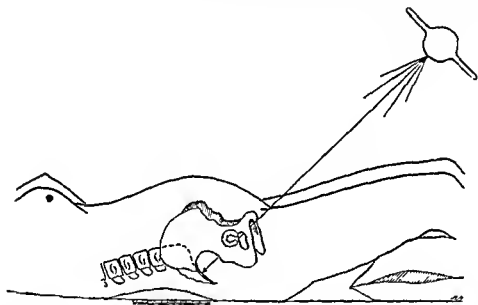


Fig 503—Schematic drawing of the positions of the tube, patient and film, and the path of the central ray

This film is a part of our routine study of pelvic anatomy and fetopelvic relationship in cases of suspected disproportion, and a description of the size, shape and anatomical peculiarities of the hiatus is incorporated in our routine report.

**Technic (Fig 503)**—The patient lies flat on her back on a Potter-Bucky diaphragm table. A folded pillow is placed under the partly flexed knees. In this position the tilt of the pelvis is increased slightly. The tube is adjusted 25 inches above the table top and is centered at the level of the anterior superior spine. It is then shifted caudal-

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<sup>†</sup> Diagnostic Roentgenology, New York, Thos Nelson & Sons, 1941, Chap 10

ward 17 inches and tilted cephalad at a 45 degree angle. To avoid confusion that results if the shadow of the symphysis is superimposed over that of the sacrum, the tube is shifted slightly (2 to 4 cm) to either



Fig 504 The upper two illustrations are examples of sacra with abnormal sacral hiatus which can be clearly seen to involve the distal half of the sacral route. The lower two illustrations are examples of relatively normal apertures. The lower left illustration has an accessory opening in the roof of the sacral canal about 1 cm from the apex of the hiatus. (From Lull Clifford B and Hingson Robert A. *Control of Pain in Childbirth*. J B Lippincott Co)

side of the midline, or the patient's pelvis can be tilted slightly to either side.

On this film (Fig 504) the shadow of the lower portion of the sacrum extends well below the level of the pubic bone, into the soft

tissue space of the subpubic angle. The shape, width and length of the sacral hiatus are clearly shown as well as any secondary openings or windows above the hiatus.

A description of these windows (Fig. 504) is important to the operator in caudal anesthesia, since after insertion of the needle through the hiatus the tip follows the posterior wall of the caudal canal. Should the tip of the needle penetrate the soft tissue of a "window" the injection would be made outside the canal and the anesthesia would be unsatisfactory.

The length of the shadow of the sacrum is distorted (lengthened) due to the angle of projection of the rays, so that accurate measure-



Fig. 505.—Caudal needle in sacral canal.

ments of the length of the hiatus or the position of a "window" cannot be made. However, the intersegmental foramina are plainly shown and serve as landmarks for the sacral segments and distance from the tip as thus indicated.

We have found no practical method of determining the anteroposterior diameter or depth of the sacral canal.

Confusing shadows of air and feces in the rectum are frequently encountered. These can usually be avoided by preliminary emptying of the rectum and sigmoid.

The method of stimulating an evacuation should be selected and ordered by the obstetrician rather than the roentgenologist to avoid stimulation of labor.

## THE ROENTGENOLOGICAL VISUALIZATION OF THE PLACENTA

PAUL A. BISHOP, M.D.\*

MANY uncertainties in the management of painless bleeding in late pregnancy are removed if the position of the placenta can be determined. Early roentgenological methods more or less naturally utilized contrast media: amniography, in which the density of the amniotic fluid was increased by the injection of diffusible opaque solutions directly into the amniotic fluid, and placentography, in which the density of the placenta itself was increased by the intravenous injection of colloidal thorium dioxide. Both methods proved dangerous to mother and child and frequently disturbed the normal progress of labor. They were never widely accepted and have now been replaced by safer methods, particularly soft tissue roentgenography, which due to improvements in equipment and technic, permits visualization of the placenta in a vast majority of cases when 50 per cent or more of the placenta lies above the level of the pelvic inlet.

**Soft Tissue Technic**—Snow and Powell<sup>1</sup> in 1934 first described a soft tissue technic for the visualization of the placenta when it was implanted in the fundus, but they had not at that time demonstrated marginal or central placenta praevia. Manges-Smith,<sup>2</sup> who began work on the same method independently, in 1932, later described his findings in 1000 cases, among which were several low implantations that he was able to diagnose correctly.

**Advantages of Soft Tissue Technic**—Soft tissue roentgenography is a simple, safe and accurate procedure that requires no special preparation of the patient, no pelvic manipulation, no injection of opaque media and is not influenced by the position of the fetus or the condition of the mother. The method, says Manges-Smith,<sup>2</sup> 'requires some study and observation and special interest on the part of the roentgenologist as well as cooperation of the obstetrician to show results. It is not however, beyond the ability of the average roentgenologist.' It has been our routine to make a single lateral roentgenogram of the fundus in all pregnant patients that we examine, not only to evaluate the development of the fetus in general and to search for multiple pregnancy, but also to perfect our technic of making satisfactory placental films and to exercise our diagnostic acumen by reporting on the placental site in each case. Our obstetrical colleagues have cooperated by reporting back to us the actual site of the placenta whenever possible after which the films are restudied and the causes of our errors deter-

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mined Because of this practice, when the rare case of suspected placenta praevia is studied, we are on familiar ground both technically and diagnostically.

**Method of Soft Tissue Roentgenography.**—A small focal spot tube is essential as are good clean intensifying screens, cassettes with perfect contact and proper dark room processing of the films The patient is placed on her side on a Potter-Bucky diaphragm table, the film and tube centered over the fundus Two exposures are made on 14 by 17



Fig. 506.—Soft tissue technic film showing the black line of the subcutaneous fat layer of the fetus

inch films, one with the tube and film centered over the middle of the posterior third of the fundus The exposure should be sufficient to record the posterior wall of the fundus For the second exposure the tube is centered over the anterior third of the fundus and the exposure is made sufficiently light to show the anterior wall These variations of density are produced by varying the voltage according to the "thickness of part technic," as used in urological roentgenography An anteroposterior film is also made with the patient lying flat on her back To avoid motion of the fetus or the mother, all exposures



pel<sup>e</sup> state that the roentgenological density of the placenta, due to the fact that it is solid tissue containing a large amount of blood, is greater than that of the amniotic fluid which is of low specific gravity. Under ideal conditions, such difference of density may exist and we are willing to agree that a layer of blood filled placenta of given thickness



Fig. 509—Moir's roentgenogram of a placenta suspended by its membranes in a wire loop (From Moir, *Am J Obst & Gynec*, Vol 47, C. V. Mosby Co)



Fig. 510—Moir's roentgenogram of the same placenta filled with amniotic fluid to demonstrate that both are of the same roentgenographic density. Compare the appearance of this shadow with the placental shadow in Figure 507 (From Moir, *Am J Obst & Gynec*, Vol 47, C. V. Mosby Co)

may be more dense than an equal layer of fluid, but since such conditions do not prevail in clinical work, we believe their point is of no practical value and that attempts to identify the placenta by any such difference of density will lead to a frustration and loss of confidence in direct placental visualization. Our opinion in this regard re

cent has been confirmed by experiments by Mour (Figs 109 and 110)

Fortunately, we are able to utilize the difference in physical characteristics in our effort to localize the placenta. The placenta is a solid organ, fixed to the uterine wall. Fetal parts cannot come close to the wall of the uterus at the site of placental attachment, but will be displaced away from the periphery. When the placenta is implanted on



Fig. 111. Lateral view of the placenta, showing the position of the placenta on the posterior wall of the uterus. Note the displacement of the fetal parts from the periphery of the uterus and the thickness of the uterine wall.

the anterior or posterior wall of the uterus the roentgenographic appearance is different in the lateral views. In Figures 109 and 110 the outline of the uterus is clearly visible. The placenta is indicated by the homogeneous shadows. Note that these shadows are up about one-third of the periphery of the uterus. The outer margin is continuous with the uterine wall and of course shadows convex. The inner margin is slightly concave but varies depending on the amount of amniotic fluid and the position of the

fetus which almost invariably faces the placenta. The average maximum thickness of the "placental" shadow is 7 cm.

It must not be assumed that the "placental" shadow should be of the size or shape of a cross section of the attached placenta. The average placenta in situ actually measures from 2 to 3 cm in thickness, much thinner than the "placental" shadow on the roentgenogram. However, due to the curve of the wall of the uterus the implanted placenta has a saucer-like form. The concavity is of course filled with amniotic fluid which casts a shadow of the same density as the placenta. As a result our x-ray shadow is a composite one, the size and

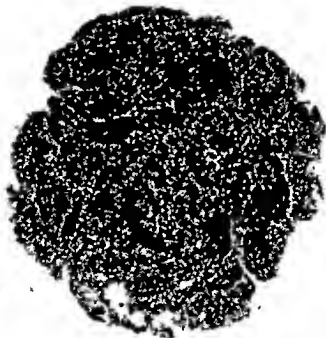


Fig 512—Roentgenogram of the calcified placenta of Figure 511, lying flat on the film

shape of the silhouette of a filled "saucer," not its cross section. This is illustrated in Figures 509 and 510. Note the similarity of shape between the "placental" shadows in Figures 507 and 508 and those of Figure 510.

The "indigitations" of extremities that have frequently been described are due to displacement of fluid by a fetal part dipping into the saucer rather than an actual pressure deformity of the placenta itself. These characteristics of the placental shadow are illustrated in Figure 511, which represents a case which has actual placental visualization due to diffuse calcification of the placenta.

In anteroposterior views soft tissue detail is not as clear as in the lateral. The fat line is rarely visible. The outline of the fundus is shown and the relation of fetal parts to the periphery can be determined. This is important in those cases in which the placenta is implanted as a lateral wall of the uterus with only margins extending to the anterior or posterior walls and producing an appearance that is not characteristic but questionable, on the lateral roentgenogram. Absence of a placental shadow on lateral views associated with displacement of fetal

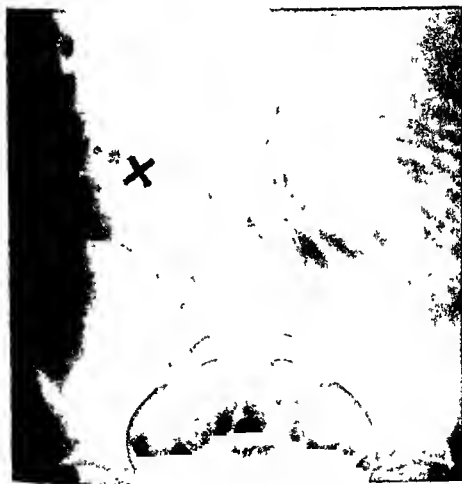


Fig 513—Lateral wall implantation of the placenta (X). Fetus displaced toward opposite side. Lateral view showed no placental shadow.

parts from an area of characteristic shape along the lateral wall of the fundus as shown in the anteroposterior view, is evidence of lateral wall implantation (Fig. 513).

If the placenta is identified in the fundus a negative diagnosis of placenta praevia as a cause for the bleeding can be made. The accuracy of this negative diagnosis should be better than 97 per cent with films of satisfactory quality.

**Marginal Implantation.**—When the placenta is implanted below the

equator of the fundus, the lower margin usually extends onto the lower uterine segment and may encroach upon or cover the internal os. Marginal implantation is suggested as a possibility whenever the main portion of the placenta is visualized on the lower half of the uterus (Figs 514 and 515). The degree of marginal implantation may be important in the clinical management of the case. Because of the wide variation of size and shape of the placenta this point cannot be



Fig. 514—Proved anterior marginal implantation of the placenta (X). The dense lateral film revealed no possible space for a placenta on the posterior wall.

judged by the amount of placenta that is visible in the soft tissue films. Further study will be of value in determining this point.

**Displacement of the Presenting Part**—If no placental shadow is identified in the abdominal portion of the uterus or if there is a low implantation, the position of the fetal head with relation to the pelvis may give useful information. Ball and Golden<sup>6</sup> state that if there is a single fetus in the vertex position (95 per cent of pregnancies) placenta praevia can be definitely ruled out if the head is dipping and not displaced from the midcoronal and midvaginal planes on antero-

posterior and lateral films made with the patient standing. Displacement of one-third the diameter of the fetal head from its usual position suggests the presence of a mass, such as a low lying placenta, ovarian cyst or uterine fibroid. A cord around the neck or a congenital short cord will cause identical displacement but high implantation of the placenta should be recognized in such cases. If the placenta is implanted low on the posterior wall, the head will be displaced anteriorly (Fig 515), while widening of the space between the head and



Fig 515—Proved posterior marginal implantation of the placenta (X). Note the forward displacement of the head.

the symphysis will occur if there is a low anterior implantation. The patient's rectum and bladder must be empty when these displacement studies are made.

**Cystography**—When soft tissue technic fails to reveal the placental site, when it shows evidence of a low implantation, or if the results are uncertain, cystography is indicated. Normally the presenting head lies directly against the lower anterior abdominal wall and causes a symmetrical crescentic pressure defect on the distended bladder (Fig

516) The normal space between the head and the bladder averages 1 or 2 cm. An interposed placenta widens this space to 5 or 6 cm (Fig. 517). The bladder should be distended with from 125 to 200 cc. of opaque solution. A 5 to 10 per cent solution of intravenous urographic media is nonirritating and nontoxic. Stereoscopic anteroposterior films are of more value than oblique and lateral films.

**Central Placenta Praevia**—We are able to report two cases in which the diagnosis of central placenta praevia was correctly made on the basis of evidence by soft tissue technic roentgenograms alone (Figs



Fig. 516—Cystogram showing the normal relationship between the head and the filled bladder

518 and 519). Normal implantation was excluded in both cases by the absence of any space of sufficient size between the fetus and the periphery of the fundus. In the first case (Fig. 518) there is a transverse lie. Fetal parts are in close contact with the periphery except in the lower central area. In the second case (Fig. 519) the head is extended and displaced into the right or left iliac fossa. Fetal parts are close to the periphery except in the lower right or left aspect. Both cases were sectioned on the basis of this roentgenological evidence and opinion and the diagnosis was confirmed.

**Premature Separation of the Placenta.**—Attempts to diagnose premature separation of a normally implanted placenta have been unsuccessful in our hands. In one case this diagnosis was made on evidence of an unusually thick placental shadow on the posterior wall of the fundus, which we felt was suggestive evidence of a blood clot. The placental localization was confined but there was no evidence of separation, bleeding, or of a clot. In retrospect, we feel the unusual width of the placental shadow was due to an unusual amount



Fig. 517.—Cystogram, proved placenta praevia, showing the abnormal space between the head and the filled bladder due to the interposed placenta

of fluid between the placenta and the fetus. Until we have had the opportunity to study films of proven cases, we are unable to suggest any roentgenographic signs of practical value in the diagnosis of this condition.

**Multiple Pregnancy.**—The presence of more than one fetus complicates the problem of identifying the placenta or placentas. We have not had sufficient experience as yet to feel positive of our opinion.

Two placentas can be identified on the film of a case of quadruplets (Fig. 520). Placenta X, which supported fetuses 1, 2 and 3,



was identified on the films on its anterior wall location and the attention of the obstetrician directed to its location prior to the cesarean

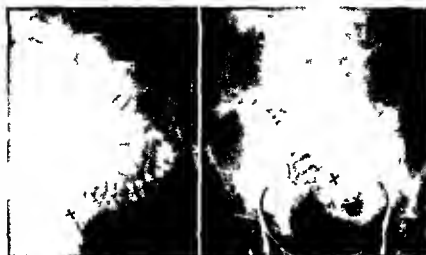


Fig 518—Central placenta praevia lateral and anteroposterior views. Note the high transverse lie fetal parts close to the periphery of the entire fundus and the absence of fetal parts in the central pelvic area (X)

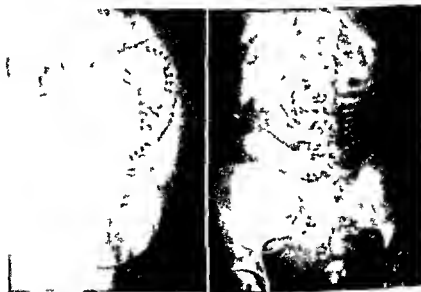


Fig 519—Central placenta praevia lateral and anteroposterior views. Note the displacement of the extended head into the right iliac fossa fetal parts close to the periphery of the entire fundus and the absence of fetal parts in the lower left and central areas

section Placenta XX supporting fetus 4 was not identified before delivery



Fig 520—Quadruplets Placenta for fetuses 1 2 and 3 at (X) on anterior wall recognized prior to cesarean section Placenta for fetus 4 at (XX) not visible

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## HEMORRHAGE OF PREGNANCY

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HEMORRHAGE is a common and serious complication of reproductive function. It, in company with toxemia of pregnancy and puerperal infection, accounts for most of the deaths in obstetric practice. Whereas at one time hemorrhage occupied the third position in this lethal triad now, because of the improvement in prenatal care, because of more effective methods of combating infection, toxemia and sepsis have sharply decreased and hemorrhage has come to occupy the first place. Hemorrhage of pregnancy will probably always cause trouble in obstetric practice for its prevention is difficult—in many cases impossible—and its treatment taxes the best of obstetric judgment and operative skill.

Hemorrhage in pregnancy may be classified according to its time of appearance—antepartum, intrapartum, or postpartum—or according to its relationship to pregnancy itself—whether extrinsic or intrinsic. The intrinsic hemorrhagic lesions are abortion, ectopic pregnancy, hydatidiform mole, placenta praevia, premature separation of the placenta, and atonic and traumatic postpartum hemorrhage. The extrinsic lesions are polyps of the cervix, varicosities of the vulva and vagina, inflammatory lesions of the lower reproductive canal, ulceration, erosion, and malignancy of the cervix. The extrinsic conditions may be encountered at any time during pregnancy, or in fact in the absence of pregnancy. In respect to the intrinsic, ectopic pregnancy and abortion are usually encountered in the first trimester of pregnancy, hydatidiform mole in the second trimester, and placenta praevia and premature separation of the placenta in the third.

There is not a great deal that is new in the diagnosis and management of hemorrhagic lesions of pregnancy, but there is much of what is already known that merits reconsideration and emphasis. The first of these is the question of diagnosis itself.

### DIAGNOSIS

Dr. Thomas McCrae, one of the greatest clinical teachers of all time, used to say that more mistakes in diagnosis were made by not looking than by not knowing. This is particularly true in obstetric practice. I have frequently commented during lecture and conference that there is no condition in the entire realm of obstetric or gynecologic practice in which a thorough and complete examination, including vaginal palpation, is not indicated. To the latter statement, the only mod-

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ifying clause which might be added is that an appropriate time and appropriate preparation for the examination must be especially arranged in certain cases

It seems superfluous to state that a diagnosis must be established before treatment can intelligently be undertaken. Nevertheless, time and time again the author has seen cases of obstetric hemorrhage lying about the hospital for days or weeks at a time on the assumption that the condition present was some such benign circumstance as a threatened abortion, no local pelvic examination having been made.

Among physicians there is a strange reluctance to perform a vaginal examination, particularly in the presence of spotting of early pregnancy, on the assumption that the performing of such will disturb the pregnancy. Actually, a gently performed vaginal examination with antiseptic preparation when necessary will not disturb or aggravate a threatened abortion, nor will it cause infection. And on the other hand, the information obtained therefrom is of such vital importance in differentiating between abortion and ectopic pregnancy that the remote possibility of disturbing the pregnancy is far outweighed by the transcendent importance of differentiating between abortion and ectopic pregnancy. Even in placenta praevia, it is essential usually to make a pelvic examination to determine the extent of the praevia and the measures which will be necessary for its treatment. In such an instance, as will be mentioned later, special surroundings and special preparations are necessary for the vaginal examination.

At the outset, however, it must be kept in mind that a thorough physical examination and a careful vaginal examination are essential to establish accurate diagnosis and to pave the way for intelligent, efficacious treatment.

#### THE EXTRINSIC CAUSES OF VAGINAL BLEEDING

In general, the bleeding during pregnancy from various extrinsic lesions of the cervix, vagina and vulva is slight in amount and intermittent in character. An exception to this statement has to be made in the case of vaginal or vulvar varices which may bleed very profusely and exsanguinate the patient if not promptly arrested. The diagnosis is established by looking for the lesion—inspection of the vulva, vagina and cervix.

Of course, the most important extrinsic lesion is carcinoma of the cervix. This may be limited in scope and difficult to recognize in pregnancy, particularly when all forms of ulcerative and erosive lesions of the cervix become hypertrophied and edematous, and bleed readily upon touch.

If there is the slightest question as to the nature of the local disease in the cervix, a biopsy should be taken. This can be performed with a biopsy punch or preferably with the loop of surgical diathermy, the crater which is left thereby being coagulated or cauterized. Com

petent pathological judgment is necessary to make a diagnosis in such cases because the cervical epithelium may be greatly hypertrophied under the influence of pregnancy hormones and simulate the appearance of a neoplasm. The diagnosis of carcinoma calls for prompt, thorough treatment, for this lesion grows with great rapidity under the stimulus of pregnancy.

### ABORTION

Abortion is by far the most common cause of vaginal bleeding during pregnancy. It is a more serious condition than full term labor and delivery. Its principal dangers are hemorrhage and sepsis, and its sequelae may be sterility and chronic invalidism. Serious sequelae are ordinarily best avoided by prompt evacuation of the uterus as soon as the abortion is known to be under way. Three questions must be answered, however, before evacuation is undertaken—first, is the abortion inevitable or is it only threatened, second, is the cervix amenable to dilatation and evacuation—are the products of conception too large to be readily evacuated, third, is infection present already in the wall of the uterus, and may it be disseminated by operative interference.

The answer to the first question consists in the differential diagnosis of threatened and inevitable abortion. An abortion may be said to be inevitable when the bleeding is free and associated with the passage of clots, when there is intermittent pain indicative of miniature labor, when there has been discharge of fluid indicating the rupture of the amniotic sac, and when the cervix is found to be effaced and the products of conception forced down into the cervical canal. When the abortion is found to be inevitable, the sooner the uterus is evacuated the less bleeding and exhaustion for the patient.

The second question as to whether the products of conception can be readily evacuated through the cervix depends upon the anatomy of this organ and also upon the size of the embryo. In some instances, it is better to prescribe small doses of oxytocic drugs such as extract of posterior pituitary in small repeated doses and give time for the cervix to dilate and permit of ready evacuation the products of conception. It may be necessary to pack the cervix and vagina for eight or twelve hours to achieve this end.

The final question as to whether there is or is not infection present in the uterine wall is an important consideration. In the presence of infection the products of conception can be removed from the cervix with an ovum forceps if they are protruding, or if bleeding is severe, a dilatation and evacuation may have to be performed to arrest hemorrhage. Otherwise, the better policy is to treat the infection systemically and disregard the local process. Generally by the time the patient has responded to systemic measures of therapy, the products of conception will have degenerated and been drained from the uter-

the cavity and the local process will have undergone spontaneous correction and involution.

In all cases of abortion, attention must also be paid to systemic replenishment of blood loss by transfusion and to the institution of chemotherapy where potential or actual infection is present.

### ECTOPIC PREGNANCY

The diagnosis of ectopic pregnancy is not always as easy as the textbooks paint it. One can always, however, make a differential diagnosis between it and abortion as has already been described and there seems no excuse for permitting a case of bleeding in early pregnancy to go unexamined on the assumption that it is a threatened abortion. Such a policy has been the cause of not a few fatalities. A more difficult diagnosis is that between ectopic pregnancy and pelvic inflammatory disease. In such cases, if fluid is felt in the posterior cul de sac, a diagnostic posterior colpotomy should be performed. In the case of pelvic inflammatory disease the drainage will be of benefit. In the case of ectopic pregnancy no great harm will be done and the colpotomy can be closed, the patient turned around, and the ectopic pregnancy operated upon through an abdominal incision.

In other instances, where a tentative diagnosis of ectopic pregnancy has been made, it is probably better to make an abdominal incision and explore than to let the patient go in doubt and unoperated upon.

### PLACENTA PRAEVIA

Much has been written concerning the x ray diagnosis of placenta praevia. This depends upon the absence of placental shadow from its normal position in the upper uterine segment, in lateral plates of the uterus taken with soft tissue technique. The measure has important diagnostic value in cases in which the bleeding is slight and prolonged and ample time is provided for such diagnostic measures. However, it should be pointed out in the instance of overwhelming painless bleeding in the last trimester of pregnancy that much time and valuable blood may be lost in sending the patient down for an x ray study with all the manipulation and change of position that is required in the effort to establish a diagnosis by such indirect methods.

In the face of rather unmistakable evidences of placenta praevia, it is my practice to prepare the operating room at once, to prepare also for transfusion in large quantities, to take the patient to the operating room, perform a vaginal examination under aseptic preparation, and if the diagnosis is confirmed, deliver the patient as promptly as possible by whichever route seems indicated.

In the case of a multipara with a partially dilated cervix and a marginal placenta praevia, rupture of the membranes, traction on the scalp with Willett forceps, or in the instance of breech presentation, bringing down one leg and tamponing the lower uterine segment with the

buttock of the child may solve the immediate difficulties and lead to a prompt vaginal delivery

However, if the cervix is closed and the bleeding is severe delivery had best be accomplished by immediate abdominal cesarean section. I prefer for this purpose the upper segment section done under local anesthesia. In order to avoid blood loss during and after operation I frequently place a firm pack in the vagina just before operating then open the abdomen and the uterus, and after extracting the baby and placenta, pack the uterus firmly down against the vaginal pack. By so doing, the lower uterine segment and vascular cervix are tamponaded between the vaginal and the intrauterine pack. Some twelve to twenty four hours after operation the vaginal pack is removed and twenty four to thirty six hours later the uterine pack is removed. Some such procedure as this will avoid the very extensive postpartum hemorrhage which often exceeds the antepartum bleeding, and may carry the patient away. Of course, in all such cases ample quantities of blood should be procured as early as possible and made available for transfusion.

#### PREMATURE SEPARATION OF THE PLACENTA

In premature separation of the placenta the x ray has no diagnostic value. The classical symptoms of bleeding, internal or external—board like rigidity of the uterus, constant severe abdominal pain and tenderness—constitute the basis for the diagnosis. The majority of cases are associated with toxemia of pregnancy or hypertension, but in not a few instances there is no recognizable etiologic factor.

Here again the diagnosis must be established by vaginal examination and is best performed in the operating room set up for either vaginal or abdominal delivery. In the presence of a closed cervix and a full term or near term pregnancy, the best treatment is abdominal cesarean section. Usually the uterus will contract firmly enough after the delivery of the placenta and fetus to make unnecessary the performance of hysterectomy. Failure of uterine contraction however calls for firm tamponade, or in some cases, hysterectomy. Hysterectomy itself may not be an easy procedure, for if the broad ligaments and uterine wall are heavily infiltrated with blood, the tissue becomes very friable and the securing of hemostasis with ligature or suture is quite difficult.

Where the cervix is partially dilated or readily dilatable as in a multipara, and particularly where the pregnancy is at a comparatively early stage, one may anticipate vaginal delivery and hasten the process with oxytocic drugs, evacuating the uterus from below when the cervix is completely dilated.

In this case too, large quantities of blood are necessary to replace that which has been lost into the reproductive tract and transfusion should be carried out during operation and afterward.

## POSTPARTUM HEMORRHAGE

Atonic and traumatic postpartum hemorrhage still take a heavy toll of the obstetric patients. Improved methods of analgesia and anesthesia and the use of more active oxytocic drugs have helped considerably to lessen the danger.

The increased use of local and regional anesthesia such as spinal, caudal, and local infiltration have resulted in a lessening of serious postpartum hemorrhage. Under such types of anesthesia the uterus is freed up from the relaxing effect of ether and the anoxemic effect of nitrous oxide anesthesia. In this direction alone much is to be said for the newer methods.

The routine administration of some active preparation of the alkaloïds of ergot either intravenously or intramuscularly at the completion of the third stage of labor has helped also to do away with the danger of postpartum hemorrhage. However, when the latter occurs and is not promptly controlled by massage and the administration of oxytocics, the uterus and vagina should be thoroughly packed. This is the promptest and most effective method of controlling severe postpartum bleeding.

I resort to intrauterine packing without hesitation in the aseptic surroundings of the hospital delivery room, feeling that it is much more important to avoid blood loss and shock than to be disturbed about the possibility of introducing bacteria into the reproductive tract. When packing is used, the prophylactic administration of penicillin or a sulfonamide, or both, may be called upon.

Instruments should always be available in the delivery room for the thorough inspection of the cervix, vaginal tract, perineum and pelvic floor for traumatic lacerations and for prompt suturing. Generally the higher the traumatic lesion in the reproductive tract the more serious the hemorrhage, although lacerations of the vaginal bulb may sometimes cause severe blood loss. In many institutions a special set of abdominal instruments is constantly on tap in the delivery room in the case of rupture of the uterus so that no time may be lost in transferring the patient to another operating room and preparing instruments and personnel there. Such preparations will unquestionably save a life here and there.



# RUPTURED UTERUS IN THE LAST TRIMESTER OF PREGNANCY

## A Report of 105 Cases

JOHN H. DUGGER, M.D.\*

RUPTURE of the uterus at or near term is a disastrous event that results in a high incidence of death to both mother and baby. In order to determine the causative factors, and to ascribe the responsibility for their occurrence, an analytical survey has been made of the 105 cases of uterine rupture occurring in the County of Philadelphia, Pennsylvania, during a ten year period. The data and conclusions are presented herewith. The preventability of the deaths and avoidable factors were decided by the Committee of Maternal Welfare of the Philadelphia County Medical Society.

A total of 318,103 live births and stillbirths occurred in Philadelphia County during the ten year period. The incidence of ruptured uterus was 1 in every 3029 births.

TABLE 1—MORTALITY ACCORDING TO THE DURATION OF LABOR IN HOURS

No. of Pregnancies	Patients	Died	Recovered
Primigravida	16	15	1
Gravida I-III	59	25	34
Gravida IV-VI	14	9	5
Gravida VII-IX	11	11	0
Gravida X or more	5	5	0
	<u>105</u>	<u>65</u>	<u>40</u>

The frequency of rupture during pregnancy was 25.8 per cent during labor, 32.4 per cent, at delivery, 40.9 per cent and one patient's uterus was perforated during manual removal of placenta.

**Previous Pregnancies**—Only one of the sixteen primigravidas recovered (Table 1). All patients who had had seven or more pregnancies died. The largest percentage of recoveries occurred among the Para I to III. This group consisted chiefly of patients who suffered a spontaneous rupture at the site of a previous cesarean section scar.

**Previous Cesarean Sections**—Thirty-four patients in whom rupture occurred had had one or more previous cesarean sections. Twenty-seven of these patients recovered and seven died (Table 2).

It was significant that the mortality in this group was relatively low. This may be attributed to several factors: first the diminished vas-

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cularity of the area in the region of the ruptured scar, which thus prevented excessive hemorrhage, second, the occurrence of the accident before the onset of labor or rupture of the membranes, thus reducing the danger from infection, third, the anticipation and prompt recognition of the condition by the attendant

**Period of Gestation**—The pregnancy terminated at or after the thirty-sixth week in eighty-five patients. Rupture occurred in twelve patients between the thirty-first and thirty-fifth week, in six patients between the twenty-sixth and thirtieth week, and in two patients between the twenty-first and twenty-fifth week.

**Presentation**—Seventy-two of the patients in the series had a vertex presentation, ten a transverse, twelve a breech, and in eleven the type was undetermined.

TABLE 2—UTERINE RUPTURE IN RELATION TO PREVIOUS CESAREAN SECTIONS

Previous Cesarean Sections	Patients	Died	Recovered
One	22	5	17
Two	8	2	6
Three	4	0	4
	<u>34</u>	<u>7</u>	<u>27</u>

TABLE 3—UTERINE RUPTURE IN RELATION TO PREVIOUS PREGNANCIES

Hours in Labor	Patients	Died	Recovered
Less than 24 hours	47	32	15
25 to 47 hours	14	11	3
48 hours or more	12	12	0
No labor	30	8	22
No report	<u>2</u>	<u>2</u>	<u>0</u>
	105	65	40

**Prenatal Care**—Adequate prenatal care is imperative for good obstetrics. Only slightly more than one half of the patients in the series had had adequate care.

**Duration of Labor**—Forty-seven patients had a labor of less than twenty-four hours. Fourteen were in labor from twenty-five to fifty-seven hours and twelve were in labor over forty-eight hours. Thirty patients had no labor, and no report was made concerning two patients. The mortality according to hours in labor is given in Table 3. The average duration of labor of the patients who died was forty hours for the primigravida and twenty-three hours for the multigravida.

**Type and Extent of Rupture**—In fifty-six patients the rupture of the uterus was spontaneous. Twenty-one of these patients died and thirty-five recovered.

In forty-five patients the rupture was of *traumatic* origin, occurring as the result of some type of manipulation by the attendant. Forty of these patients died and only five recovered. Four died undelivered.

The rupture was *complete* (Fig 521) in eighty-three patients and *incomplete* (Fig 522) in eighteen patients.

Analysis of the method of delivery was most illuminating. Rupture of the uterus occurred in eight patients in whom the delivery was

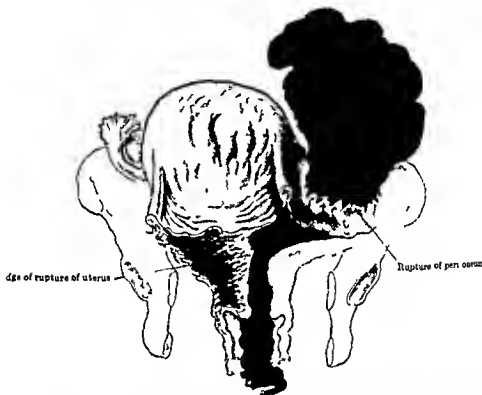


Fig 521—Diagram of complete uterine rupture. Hematoma burst during the tossing about of the patient. (From DeLee and Greenhill Principles of Obstetrics.)

spontaneous. For the larger number, ninety-three, an operative delivery was performed. Four patients died undelivered.

**Spontaneous Deliveries**—Of the eight patients who delivered spontaneously, five died. Important factors in these deaths were manual dilatation of the cervix and the injudicious use of posterior pituitary extract.

An example of a preventable death in this group, due to an error in judgment, is seen in the following case history.

Mrs. D. H., a primigravida who had had no prenatal care, was pregnant six months when admitted to the hospital in convulsions. Immediate treatment for

toxemia included manual dilatation of the cervix and rupture of the membranes. Thirty six hours later the convulsions had ceased. The patient improved. Three minims of posterior pituitary extract were given at fifteen minute intervals for four doses. A rapid spontaneous delivery resulted but this was followed by shock and hemorrhage. Death occurred five hours after delivery and autopsy revealed an incompletely ruptured uterus with extensive subperitoneal hemorrhage.

Three patients recovered from the rupture following spontaneous delivery. Two were treated by supravaginal hysterectomy. One patient had no further treatment.

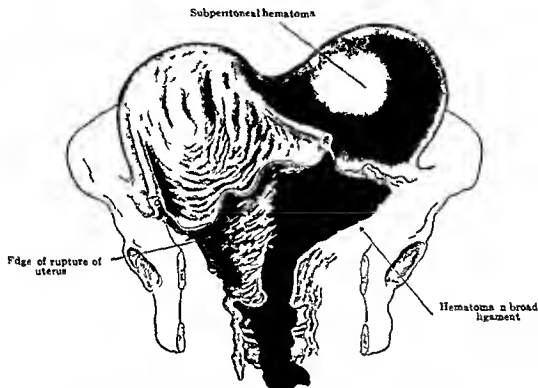


Fig 522—Diagram of incomplete uterine rupture. Broad ligament unfolded and distended by immense hematoma. (From DeLee and Greenhill Principles of Obstetrics.)

Mrs S. B., age 35, was in her fourth pregnancy. The first and second pregnancies had terminated in normal vaginal deliveries. The third delivery was by cesarean section in the presence of toxemia and a twin pregnancy. The present pregnancy at term was complicated by toxemia and premature separation of the placenta. After seven and one half hours of labor a spontaneous delivery occurred. Vaginal examination revealed an incomplete rupture of the uterus. As the general condition of the patient was good, no further treatment was administered and the patient made a complete recovery.

This was the only patient in the entire series who recovered from a rupture of the uterus without treatment.

**Operative Deliveries—Low Forceps**—Five patients who were delivered by outlet forceps died. Three of these deaths were preventable and two were nonpreventable. The associated errors in judgment

technic were responsible for the rupture, and not the outlet forceps operation.

As an example of errors in judgment and technic in this group a brief history is cited.

Mrs M. D., a primigravida, was at term. During her labor 1 cc. of posterior pituitary extract was administered. After six and one half hours of labor the incompletely dilated cervix was incised and delivery was completed by means of outlet forceps. The patient died.

Death from the ruptured uterus was caused by the injudicious use of an oxytocic drug, incising the cervix, and too early operative interference.

*Mid and High Forceps*—Eight patients were delivered by mid or high forceps, all died. The deaths were considered preventable due to errors in judgment or technic on the part of attendants.

*Midforceps*—Three patients were delivered by midforceps.

Mrs F. J. had had one previous delivery, which was instrumental. The current prenatal care was inadequate. Upon examination the pelvis was found to be slightly contracted. Labor was induced at term with castor oil and posterior pituitary extract, the latter being administered in 5 minims doses by hypodermic injection repeated at fifteen minute intervals for five doses. After thirty-six hours of active labor the patient was delivered of a stillborn infant by midforceps. Death from shock and hemorrhage occurred six hours after delivery, and autopsy revealed a complete rupture of the uterus.

This death was considered preventable due to the failure of the physician to recognize and properly treat the cephalopelvic disproportion. Cesarean section should have been performed after a trial labor.

Mrs A. A., a primigravida aged 29 years, was at term. The prenatal care had been adequate. X-ray studies revealed a relative cephalopelvic disproportion and a deformed pelvis. The onset of labor was spontaneous and after thirty-three hours of labor attempted delivery by midforceps was unsuccessful. Two hours later a second difficult midforceps operation was performed and a stillborn infant was delivered. Death from sepsis occurred fourteen days later. A postmortem examination revealed an incomplete rupture in the lower uterine segment.

This patient should have been delivered by cesarean section after a trial labor. Her death, which was preventable, was due to the failure of the attending physician to recognize the disproportion and deliver the patient by cesarean section.

*High Forceps*—Five patients were delivered by high forceps. The following case report demonstrates the unfortunate results to be expected when delivery by high forceps is attempted.

Mrs McC., aged 33 years, had had one previous pregnancy which was terminated by a high forceps delivery. The child was stillborn. The prenatal care was inadequate and the patient on admission was suffering from preeclampsia. Onset of labor was spontaneous at term. After a labor of twenty-six hours she was given 3 minims of posterior pituitary extract and the membranes were ruptured.

artificially. The vertex was presenting at the pelvic inlet. The patient continued in labor for one hour when a high forceps delivery was accomplished with difficulty. The infant was stillborn and the mother died two and one half hours after delivery. A complete traumatic rupture was detected on postmortem vaginal examination.

This preventable death was due to errors in judgment and technic. The patient should have been delivered earlier and by cesarean section. The avoidable factors were failure to recognize the existing cephalopelvic disproportion, the injudicious use of posterior pituitary extract and the application of forceps to a floating head. Attention to the history of previous delivery would have been most helpful.

**Version**—Rupture of the uterus occurred in thirty patients upon whom *internal podalic* version was employed. Only two of these patients recovered. Twenty-eight, or 40 per cent, of all the maternal deaths in the present series, and twenty-three, or 34.8 per cent, of the fetal deaths, occurred in cases in which the patients were delivered by internal podalic version. According to Schumann,<sup>2</sup> 'Ruptured uterus is a too frequent sequel to version'. There were 2480 versions performed in Philadelphia during this ten year period. The incidence of ruptured uterus was 1 for every 121 patients delivered by internal podalic version. The maternal dangers to be feared from internal podalic version are rupture of the uterus, detachment of the placenta, lacerations to the birth canal and subsequent infection. The dangers to the infant are trauma, with resulting intracranial hemorrhage and asphyxia. The attendant should never attempt internal podalic version until the indications and contraindications are carefully considered.

The following history illustrates the danger of attempting delivery by version too early in labor.

Mrs. E. M., aged 28 years, had had one previous full term pregnancy which was terminated by a difficult forceps operation. The current prenatal care was inadequate. After a ten hour labor the head was in the midpelvis and the cervix was incompletely dilated. An attempted forceps delivery at this time was unsuccessful. A consultant was called who performed an internal podalic version and delivered the patient. Intrauterine examination revealed a complete traumatic rupture of the uterus. Emergency laparotomy and supravaginal hysterectomy were performed. Death occurred seven days after delivery.

The death in this instance was attributable to the attempts at forceps delivery and version too early in the labor, and thus was preventable. These errors in judgment were attributed to both the attendant and his consultant.

**Breech Presentation**—Breech presentation occurred nine times. Two patients recovered and seven died. Each of the seven patients who died presented difficult obstetric problems. Five of the deaths were considered preventable and two nonpreventable. The preventable deaths were attributed to errors in judgment and technic on the part of attending physicians in four cases. One death was considered to be due

to lack of cooperation on the part of the patient, and thus was preventable.

An example of a preventable death in this group, which was due to an error in technique on the part of the physician, is seen in the report which follows

Mrs. L. S., aged 26 years, was a primipara. Prenatal care was adequate. Labor was induced by intranasal administration of posterior pituitary extract. After sixteen hours of labor a frank breech was decomposed. When the physician delivered the first foot and introduced his hand into the uterine cavity to grasp the second foot, he felt the thinned overstretched uterine wall rupture. By immediate classical cesarean section a living infant was delivered. The small rupture on the lateral wall of the lower uterine segment was not sutured. Death occurred four days later.

A preventable death ascribable to lack of cooperation on the part of the patient is illustrated next.

Mrs. McC. was in her seventh pregnancy. All her previous pregnancies had terminated in normal spontaneous vaginal deliveries. The patient had no prenatal care and refused hospitalization at the onset of labor. After eight and one half hours of labor breech extraction was attempted but it was unsuccessful. The patient was referred to the hospital where she was given a blood transfusion, and cesarean section followed by supravaginal hysterectomy was performed. The 11 pound infant which was delivered showed evidence of postmaturity. The patient had suffered a complete traumatic rupture of the uterus and died eight days after delivery.

The failure of this patient to accept hospitalization on the advice of her physician undoubtedly compelled him to choose an undesirable method of delivery.

The two patients who recovered each had an easy breech extraction. Each had an incomplete rupture recognized by vaginal examination. Each made an uneventful recovery following supravaginal hysterectomy and repeated blood transfusions.

**Undelivered Patients.**—There were four patients who died undelivered. For all of these, home deliveries had been planned. Two were under the care of senior medical students, one was cared for by a physician, and one by a midwife.

The deaths were all considered to be due to errors in judgment or technique on the part of the attendants, and thus were preventable.

Mrs. G. G., aged 33 years, had had four previous long difficult labors. Currently, she had no prenatal care. Labor began spontaneously at term but after six and one half hours of labor the midwife who was in attendance called a physician who recognized the transverse position of the fetus and referred the patient to the hospital where she died before delivery was attempted. Autopsy revealed a complete rupture of the uterus.

Mrs. M. A., aged 28 years, had had two previous full term pregnancies with spontaneous deliveries. Current prenatal care was inadequate. The onset of her labor was spontaneous. After fifteen hours of labor at her home the medical student who was in attendance called a consultant who referred the patient to the hospital, where it was found that an impacted mandible was presenting.

Death occurred before any treatment could be administered. A complete rupture of the uterus was found at postmortem cesarean section.

The death in this instance was attributable to the failure of the attendant to recognize and treat the abnormal condition. It was thus preventable.

**Mortality and Preventability**—The total maternal mortality in Philadelphia for the period covered by this survey, from all causes except ectopic pregnancy and abortions, was 974 deaths. The total of deaths from ruptured uterus was sixty-five (6.6 per cent).

In this series of 105 cases there were sixty-five maternal deaths and sixty-six fetal deaths, that is a mortality of 61 per cent and 62 per cent respectively. Deaths from rupture of the uterus were usually preventable. Of the deaths, 76.9 per cent were considered to be due to errors in judgment or technic by the attending physicians and 7.7 per cent were attributed to lack of cooperation on the part of the patient.

TABLE 4—MORTALITY

	Number	Per cent
Preventable deaths	55	84.6
Nonpreventable deaths	10	15.4
	65	100.0

TABLE 5—PREVENTABLE DEATHS AND AVOIDABLE FACTORS

Attributed to	Patients	Per cent
1 Errors in judgment or technic by the physician	50	90.9
2 Ignorance or lack of cooperation on part of patient	5	9.1
	55	100.0

All of these deaths were preventable. Only 15.4 per cent of the deaths were considered nonpreventable.

Constant education of the public, accomplished through the renewed and persistent efforts of organized medicine, is necessary if the present high maternal mortality rate is to be reduced. The lay public must know what constitutes adequate care and should discriminate against the unqualified attendant.

Bland<sup>1</sup> has said: "No function is performed by the human body with greater danger than is pregnancy with its termination in labor. No process customarily described as physiologic is so frequently associated with complications."

Emphasis should be placed on the quality of the medical care given the patient. That the professional care which some of the patients received was of poor quality is obvious. Thirteen patients had no pelvic measurements taken. Nine patients with recorded contracted pelvis were delivered by vagina, but without roentgen studies. Patients with unrecognized abnormal presentations such as a shoulder, or with a



hydrocephalic fetus were permitted to undergo long exhaustive labor before delivery was attempted. Posterior pituitary extract was administered to one patient during a normal labor. Improper operative procedures, unskillfully performed, were attempted too often.

*Roentgenography* was employed for only three patients and in each of these it revealed the abnormal condition. However, it was used only *after* the patient was potentially infected and when she was suffering from near exhaustion due to a long labor. This made any operative procedure dangerous to both the mother and the baby. In all three patients who were studied by roentgenography, the deaths were considered preventable due to errors in judgment and technique. The history of one of the cases is cited to illustrate this point.

Mrs. M. P. Para IX was admitted to the hospital in the thirty-sixth week of pregnancy, and treated for severe preeclampsia. Medical induction of labor was attempted but proved unsuccessful, whereupon surgical induction by manual dilatation of the cervix and rupture of the membranes was performed. After forty-eight hours of labor the roentgenogram showed the fetus to be in the transverse position with an impacted shoulder presenting at the pelvic inlet. After fifty-seven hours of labor an internal podalic version was undertaken. The result was a complete traumatic rupture of the uterus, a stillborn infant and death of the mother four days after delivery.

Roentgenographic studies of the other two patients showed abnormal pelvis with relative disproportion. Both patients had been in labor for some time and vaginal delivery by high forceps was the procedure undertaken. In all three cases roentgen studies at a time when a conservative plan of delivery could be followed would have revealed the abnormality.

**Posterior Pituitary Extract**—The danger of administering posterior pituitary extract to a patient *during* labor is illustrated by the following case report.

Mrs. E. C. aged 26 years who had had two previous spontaneous deliveries was at term. The current pregnancy had been uneventful. The membranes ruptured at the onset of labor. Two hours later she was examined by her physician who found a frank breech presenting at the pelvic inlet. The cervix was only 2 cm. dilated and one third effaced. One cubic centimeter of posterior pituitary extract was given subcutaneously, whereupon the uterine contractions became strong and prolonged. Two hours later a second dose of 1 cc. of posterior pituitary extract was administered. Severe tetanic contractions followed. Three hours later the patient was referred to the hospital suffering from shock and symptoms of intra-abdominal hemorrhage. The abdomen was irregular in shape and the fetal parts were easily palpated. Emergency laparotomy revealed a ruptured uterus at the onset of labor. Two hours later she was examined by her physician, peritoneal cavity and a supravaginal hysterectomy was performed. After repeated blood transfusions and a prolonged illness the patient recovered.

#### PREVENTION AND TREATMENT

The prevention of ruptured uterus must be accomplished through an improvement in the technical skill and judgment of the obstetrician.

The attendant should not attempt to carry out procedures for which he is not adequately prepared by experience and training. He is advised to secure prompt and competent consultation in the presence of abnormal conditions in all obstetric patients.

In the treatment of a threatened rupture it is necessary first to decide whether to terminate the labor by vaginal or abdominal delivery. Generally, if there is present a partially dilated cervix, fetomaternal disproportion, malposition or an unengaged presenting part, delivery by cesarean section is the method of choice. If the presenting part has descended below the ischial spines, vaginal delivery, employing the utmost gentleness and slowness of traction, is usually indicated.

When actual rupture has occurred, laparotomy with hysterectomy or repair of the rupture is the procedure of choice, since the risk from infection would probably be less than the danger of death from shock and hemorrhage.

The prompt treatment of the shock and hemorrhage before, during and after operation is always indicated. Whole blood transfusion is imperative. The condition of the patient often may be helped by temporary measures of giving intravenously, glucose 5 per cent in sterile distilled water, plasma or physiological salt solution to be followed by whole blood.

Penicillin should be given to those patients in whom infection is present or anticipated. The prevention of infection in these critically ill patients is imperative since they may survive the immediate shock and blood loss only to succumb to infection later.

These important principles of successful treatment are illustrated in the following cited case.

Mrs. M. M., aged 30 years, had had one previous pregnancy which was terminated by cesarean section for painless vaginal bleeding. The puerperal period was afebrile. The current prenatal care was adequate. The patient was informed of the possibility of rupture of the uterus. Labor was induced by administering 2 ounces of castor oil and a hot soap enema; no oxytocic drug was given. The patient was observed by her attendant during the labor with the hope that she could be delivered by vagina. After six hours of mild labor, a severe continuous pain developed in the lower part of the abdomen and the uterus remained contracted. A diagnosis of ruptured uterus was made, and emergency cesarean section was performed eighteen minutes after onset of the severe pain. Immediate operation was possible because the obstetrician had requested in advance that the operating room staff be prepared. Efficient cooperation permitted the operation to be started without loss of time.

The living infant was free in the peritoneal cavity. The placenta, still attached in the uterine cavity, was functioning. A supravaginal hysterectomy was performed and simultaneously a blood transfusion was given. The mother and infant both recovered.

#### CONCLUSIONS

1. A series of 105 cases of ruptured uterus at or near term occurring in Philadelphia County over a ten year period has been studied.
2. Sixty-five patients died and forty recovered.

3 All the records of the patients who died from ruptured uterus were studied by the Committee of Maternal Welfare of the Philadelphia County Medical Society. The preventability and avoidable factors were determined by this committee.

4 The incidence of ruptured uterus was 1 in every 3029 births.

5 Fifty six, or 86.1 per cent, of the deaths occurred following operative delivery.

6 Internal podalic version was the most frequent method of delivery associated with ruptured uterus.

7 Fifty five, or 84.6 per cent, of all deaths were preventable.

8 Adequate prenatal care, competent obstetric judgment, and skillfully performed deliveries will reduce the too frequent occurrence of ruptured uterus.

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# UTERINE CONTRACTIONS DURING PREGNANCY AND LABOR OBSERVED WITH THE TOCOGRAPH

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THE nature of the uterine contractions is one of the many mysteries and difficulties which confront the obstetrician. There have been numerous efforts and techniques described to evaluate and predict their force. One of the simplest and most practical instruments devised to answer this question is the Lorand toco-graph. It is intended to review the results which have been obtained with this instrument in the study of uterine motility.

Two general methods are used to register uterine contraction: those with an internal receptor, either intravaginal, intrauterine or intra-rectal, and those with an external receptor which is put on the abdominal wall. The internal receptors record movements transmitted by means of a balloon containing either air or water that is placed in the uterus, vagina or rectum. These receptors have the disadvantage of introducing infection, being difficult to use, and frequently causing pain and discomfort to the patient. These also transmit, besides the uterine contractions, the cardiac movements of the mother, as well as abdominal straining and other voluntary motions. Furthermore, their insertion often produces abnormal uterine contractions. The external method registers the movement of the uterus transmitted through the abdominal wall. In this method the instrument is strapped or fastened on the abdomen during the time of measurement. It has the advantage of not introducing infection, ease of application and of being by far the simplest type of recording device. The dampening effect of the abdominal wall is not, as would be anticipated, particularly detrimental in obtaining the uterine motility pattern.

**Description of the Tocograph**—Using the external method, Lorand in 1933 constructed his first toco-graph.<sup>1</sup> The instrument has been remodeled and at present consists of an external type of receptor which is combined with a small continuously recording kymograph.<sup>2</sup> The instrument consists of a metal box about the size of a pack of cigarettes. A small rod projects about 0.5 cm. from the bottom of the box and is connected through a lever mechanism to a pen which magnifies the movements of this rod approximately five times. This pen records on a strip of millimeter cross section paper which is moved at the rate of 1 cm. in two minutes by a spring driven clock.

**Operation of the Tocograph**—A new instrument is carefully inspected to see that all working parts move easily with a minimum of

play. Two calibrations are necessary. The spring controlling the tension on the writing mechanism must be adjusted so that 150 gm of pressure on the receptor rod lifts the pen to the middle of the graph paper strip. This calibration is accomplished by placing 150 gm on one pan of a simple laboratory balance and slowly allowing the tocograph receptor rod to press on the other balance pan. Secondly, the clock mechanism is adjusted so that the graph paper strip moves at the rate of 1 cm in two minutes. This can usually be accomplished by the adjustment on the clock balance wheel. In operation the instrument is

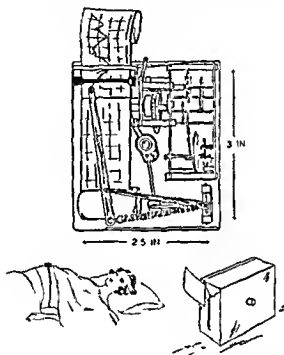


Fig 523—Latest model Lorand tocograph interior and exterior views and in position for recording. Movement of recording button projecting 0.5 cm from bottom of tocograph is magnified five times by writing pen. This instrument is smaller and simpler in construction than model shown in earlier report<sup>2</sup> (Douglas P. Murphy in *Surgery Gynecology and Obstetrics* Volume 73).

fitted with a small roll of paper, the pen inked and the clock mechanism started. It is then fastened to the abdomen at the most prominent portion of the fundus by an elastic belt. After minor but necessary adjustments a continuous recording of uterine motion is obtained on the strip of graph paper.

The instrument, like all mechanical gadgets, must be watched continually during its operation. Frequent minor adjustments, replacement of ink, changing the position of the patient and other tricks that are learned through experience make the difference between a perfect

record and a failure. At the completion of each case the machine is carefully cleaned and inspected to insure continuous service.

The instrument is subject to a 5 to 10 per cent error in its operation. This error is not particularly significant as the errors of one individual machine tend to be constant and thus effect equal results on graphs. Only when tracings of several machines are compared do they become significant. The tocograph is by no means a self-operating device that can be left unattended. Careful and constant clinical observation during the entire recording period is necessary. All observations and significant factors are recorded in a notebook using the numbers on the upper margin of the graph paper as reference points. These notebook records are an essential and integral part of every tracing. In evaluating the final record not only must the tracing and the record of clinical observation be considered but also the mechanical errors and the clinical condition of the patient. A tracing without this supplementary information is worthless.

**Reading and Interpretation of Records.**—The tocograph supplies a permanent record which makes possible the measuring and evaluation

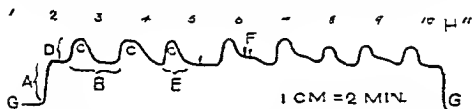


FIG. 174.—A tocograph tracing of normal labor modified to illustrate *A* time, *B* frequency, *C* rhythm, *D* strength, and *E* duration of contractions. *F* represents fetal movements and *G* the base line of the resting pen. *H* Reference numerals for the location of clinical data. (Actual size total duration twenty minutes.)

of five characteristics of uterine activity: (*a*) the hardness or tone of the uterine wall, (*b*) the frequency, (*c*) rhythm of occurrence of the intermittent contractions, (*d*) their strength, and (*e*) their duration. The first of these characteristics, the hardness or tone of the uterine wall, cannot be measured in absolute terms by an external receptor apparatus nor can any correlation be made between tocograph readings and internal hysterographic measurements. It is noted, however, in a relative degree and is expressed in terms of the displacement of the writing pen from its rest point which occurs when the machine is placed on the patient's abdomen. If the uterus is soft, the recording button sinks into the abdominal wall and the pen is not displaced. This is termed zero hardness or tone. If the uterus is hard or tense the pen moves up from the zero position; the distance it traverses expressed in millimeters, gives a comparative measurement of the tone of the uterus.<sup>12</sup> This factor of uterine tone is a very important portion of all tocographic tracings. Its accuracy is dependent upon the careful calibrations of the instrument.

The *frequency* of the uterine contractions is expressed in the number of contractions per minute or hour and is determined by measuring the distance between corresponding points of adjacent waves. These measurements are carried out with a caliper and are then checked with the speed which the graph paper moves. The usual speed of the average instrument is a centimeter every two minutes and is constant for all practical purposes. The contractions recorded by the tocograph are much more accurate than those recorded clinically. The *rhythm* of contractions is based upon the time interval between the start of one wave and that of the next and is expressed as a coefficient of variation.<sup>1</sup> Also in rhythm enters to a certain extent the wave shape or contour which is determined by the observation of several waves and the ability to superimpose one on the other rather than by actual measurement. The *strength* of the contraction is measured by the height of the contracting waves and is expressed in millimeters. The measurement is taken from the base of the valley between the waves to the crest. This as well as tone is dependent upon the spring tension of the instrument. The *duration* of the contraction is measured in terms of the length of the contraction waves and is expressed in seconds. It is usually measured by calipers from the first upward swing of the writing pen to the last downward swing of the contraction. There are also other markings which occur on the tocographic tracings. These are: First the fetal movement which is registered by short vertical lines with no duration and with no semblance of regularity either as to size or recurrence. From these lines can be deduced the presence of a living fetus. Second other irregularities which occur due to vomiting, coughing and large abdominal movements of the mother and bearing down in the late second stage of labor.

In order to evaluate properly any tocographic reading the actual mechanics of the instrument must be carefully considered. There are numerous mechanical errors which arise from wear and tear on the instrument. These can be corrected only by very careful inspection and frequent checking as to the time and spring tension of the mechanism. The friction of the moving receptor rod which rests on the abdomen is frequently increased by perspiration and foreign material working into this area. Other errors arise from the movement of the patient, the turning and straining of the patient and other factors which must be evaluated from the clinical notes taken during the recording.

#### TOCOGRAPHIC MEASUREMENTS OF NORMAL PREGNANCY AND LABOR

**Normal Pregnancy**—By following a normal pregnancy with frequent tocographic tracings it has been noted<sup>11</sup> that the earliest fetal movement occurred at 18½ weeks, the earliest uterine contractions and

rhythm occurred at 23½ weeks, and the earliest increase in tension of tone occurred at 31 weeks. These recordings are a summary of a series of tocomographic tracings based upon the assumption that pregnancy lasts 280 days, with due consideration of fetal development and menstrual history. The contractions which were first recorded in the 23rd week recurred with increasing frequency, but this increase was not uniform, first becoming significant during the 32nd week of gestation. Only 70 per cent of the tracings recorded the presence of contractions during the last month and only 84 per cent during the last week of pregnancy.

Rhythm appeared as early in pregnancy as contractions, but was observed less frequently. Its incidence increased as pregnancy progressed, and like contractions the greatest rate of increase occurred about the 32nd week of gestation. During the last month rhythm appeared in only 35 per cent and during the last week, in only 60 per cent of tracings. Increase in tension of the uterine wall, which occurred at the 31st week, resembled the other two characteristics in that it showed the greatest increase at the 32nd week. During the last month, it was present in only 43 per cent of the tracings and during the last week, in only 52 per cent.

In correlating the above facts with the length of labor, it is noted that the average duration of labor was shorter in the small number of patients who had contractions before the 33rd week. The appearance of rhythm and increase in tension had no effect upon the duration of labor.

Focusing our attention on uterine activity during the last two months of pregnancy, wide individual variations are noted in all characteristics. As in early pregnancy, contractions continue to be the most important prognostic characteristics of labor. During the last month the frequency of contractions tends to stabilize but their strength diminishes during the 37th to the 39th week, this is followed by an increase in strength and duration in the 39th to 40th week. This quiescent period has not been adequately explained. Short labors normally show contraction waves which tend to be superimposable, that is, they show a nearly perfect rhythm of size, shape, duration and frequency. This pattern should be preferably associated with infrequent, strong and long contractions. Several observations in late pregnancy are necessary to properly visualize this general over-all picture of ideal prelabor uterine activity.<sup>12</sup>

To recapitulate: Uterine activity increases progressively during pregnancy from the 23rd week, its greatest increase taking place in the middle of pregnancy about the 32nd week. Patients experiencing uterine contractions prior to the 32nd week of gestation have markedly shorter labors than those who did not have such activity. The picture of the ideal prelabor uterine dynamics is one of regular, forceful contractions.



**Normal Labor**—Normal labor is characterized by a pattern in which it is possible to superimpose any one contraction wave and its following trough upon either of its adjacent waves and their respective troughs. The nearer this ideal can be approached the better is the quality of uterine motility. This rule holds throughout labor even though the magnitude of the waves may be small. The earlier large waves are established the more rapid will be the progress of labor. Good uterine motility during labor can be predicted even before the onset of labor if a pattern of contraction measuring up to the above criteria is established. Each individual possesses a distinctive contraction pattern during pregnancy which in a modified form is carried over into labor. The persistence of this pattern makes it possible to prognosticate early in labor the probable subsequent course. Usually two tracings about one hour apart are sufficient to obtain the pattern. Such observations make possible the detection of poor quality irregular uterine contractions relatively early, and thus expedite the treatment of primary inertia.<sup>18</sup>

During the course of labor a progressive change in uterine activity occurs: there is an increase in uterine tonus, strength and frequency of the intermittent contractions and total amount of energy expended. A fact perhaps not hitherto suspected is that the duration of contractions decreases rather than increases. Patients with a low tonus and high contraction waves have the more rapid deliveries. Observing the characteristic of tonus it is noted that primiparas have a higher tonus throughout labor than multiparas, especially the first stage and with this higher tonus compensatory lower contraction waves.<sup>19</sup> As this is not the ideal picture of labor it may possibly be an additional reason for the longer periods of labor in primiparas as a group. This observation also suggests the advisability of utilizing in the delivery of primiparas those methods which are directed especially at the lowering of tonus. In this connection caudal analgesia should be valuable as 40 per cent of patients under this analgesia show a progressive decrease in uterine tone not related to the level of analgesia.<sup>24</sup>

#### ABNORMAL LABORS

**False Labor**—In an effort to diagnose false labor and to determine if there is any particular contraction pattern associated with it a series of patients were studied. It was found that the contraction pattern of false labor may resemble that of either pregnancy or true labor. This fact leads to the conclusion that there is no significant factor in the tocographic tracing that can be utilized to distinguish between false and true labor. In the series two patients who experienced unusually early false labors gave birth to the only two premature infants. This association of premature births with early false labors suggests the importance of careful study and treatment of such patients.<sup>9</sup>

**inertia**—The tocographic pattern of primary inertia is characterized

by small arrhythmic contraction waves which fail to resemble each other in shape or magnitude. These contractions can be superimposed on either low, normal or high tone. The treatment varies with the tone. In the cases in which the tone is low, small dosage of oxytocic drugs may be employed with safety. However, in the high tone uterus, it is better to reduce the tone by rupture of the membranes or by the use of caudal or spinal analgesia. Oxytocic drugs should not be employed as tetanic contractions may result. If a tocographic record gives evidence of primary inertia early in labor, one of two sequelae is to be suspected. Either primary inertia will continue or uterine contractions will cease altogether, the primary becoming a secondary inertia. As yet, a secondary inertia has not been observed to follow an earlier normal uterine motility in the absence of disproportion. Tocographic records thus indicate not only the existence of primary inertia, but also its degree and type. Furthermore, by continued obser-

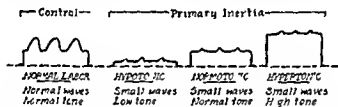


Fig 525—Lorand's classification of primary inertias. Diagrammatic representation of tocograph picture of (a) normal labor, (b) hypotonic, normotonic and hypertonic primary inertia. Note (a) small size of waves in all types of primary inertia, (b) different degrees of uterine tone associated with the small waves of primary inertia. (Douglas P. Murphy in *Surgery, Gynecology and Obstetrics*, Vol. 77.)

vation of the tracings, the first appearance of secondary inertia can be noted.<sup>4, 18</sup>

**Dystocia.**—Present observations indicate that dystocia increases the effort of the uterus. It augments the already high tonus, but not the contraction height of primiparas. In multiparas the height of contractions is increased but not the tone. Dystocia prolongs the duration of the contractions of all patients.<sup>16</sup> The finding of markedly increased tonus and prolonged contractions during labor suggests a definite disproportion and the labor should be conducted accordingly.<sup>17</sup>

**Abruptio of the Placenta.**—Of interest in the tocographic tracings of patients with abruptio placentae is the fact that none of them record any of the intermittent contractions which occur during late pregnancy and normal labor. This is confirmed clinically by the continuously tense abdomen. This fact raises the question as to whether the usual intermittent contractions are necessary for the opening of the cervix, since the cases of abruptio show that in the presence of high uterine tone labor and delivery may go to completion.<sup>15</sup> Tocographic

readings have never recorded a labor in the absence of both intermittent contractions and a persistently high uterine tone<sup>23</sup>

**Abdominal Pregnancy**—The tocograph has been used diagnostically in several cases of abdominal pregnancy. In true abdominal pregnancy near term, the tocograph will show the absence of a contracting uterine wall and, in the case of a living fetus, active fetal movements. These findings have been utilized in the diagnosis of a case of abdominal pregnancy which is to be reported.

**Abnormal Uteri**—In the case of bicornuate uteri or uterus subseptis with a single fetus, tocographic tracings have shown that the resting tone and the contractions of the two horns of the uterus are not equal, the pregnant horn showing an increased tone and an increased duration of contractions.<sup>3</sup> In cases of hydramnion the resting tone of the uterus has been shown to be twice that of the normal pregnancy, while it is only slightly increased in patients with extremely large babies.<sup>2</sup>

**Posterior Occiput**—Tocographic tracings have shown that the anterior rotation of the occiput does not depend upon the quality or strength of uterine contractions, or upon the size of the infant. It is probable that the most important factor in the anterior rotations is the type of pelvis rather than the uterine force.<sup>22</sup>

## DRUGS

**Pitocin**—The previous discussion has dealt with the individual variability, parity, duration of pregnancy, normal and abnormal labor and other factors. The effects of drugs on uterine dynamics will now be presented. By recording the response of the pregnant uterus to pitocin it was found that those with a significant response had shorter labors. Furthermore, women having uncomplicated clonic reactions had significantly shorter labors than those who exhibited a tendency toward tetanic spasm. It is thus possible by measuring the response of the uterus to pitocin, to predict the relative duration of labor.<sup>10</sup> In avoiding unsatisfactory types of uterine contraction to pitocin the tocographic tracings indicate that the tension of the uterine wall at the time of treatment and the dosage of pitocin are the most important factors. The size of the dose and the indications for pitocin should therefore be governed by uterine tone. This principle was previously discussed in relation to inertia. Also the additional fact that the reaction of the uterus to pitocin increases progressively as pregnancy advances must be considered in the use of this drug.

**Estrogens**—The oxytocic effect of intramuscular estrogenic substances is variable. After the 29th week the effect on the tone and the characteristics of uterine contractions increased irregularly as pregnancy advanced. During labor the estrogenic substances appeared slightly to affect only uterine tone.<sup>19</sup> It is possible that future observa-

tions using intravenous hormones will show more striking and practical effects

### ANESTHESIA

**Sedation with General Anesthesia**—After administration of as small a dose as  $\frac{1}{4}$  grain of morphine in labor, tocographic tracings show a cessation of fetal movements within ten minutes. This dosage has no apparent effects on the uterine activity,<sup>2</sup> however when ether anesthesia is superimposed the uterus relaxes and the tone and contractions are reduced.

**Caudal Analgesia**—In following patients under caudal analgesia, the most important factor affecting uterine motility was the level to which analgesia ascended. When the level of analgesia was maintained below the 10th thoracic segment 80 per cent of the labors were unaffected and the remainder showed only minor changes in motility. When the analgesia ascended above the 4th thoracic segment, almost 70 per cent of the patients showed a decrease in uterine motility. In extremely low analgesia, involving only the sacral nerves some cases showed a marked improvement in the strength and frequency of uterine contractions, this improvement continued after the analgesia ascended to the 11th thoracic segment. Approximately half of the patients studied showed a progressive decrease in uterine tone which did not appear to be related to the level of analgesia.<sup>3,4</sup> This decrease in tone may have particular significance in the hypertonic type of meruia; it is also interesting to note that the tone in primiparas is higher than that in multiparas and it is frequently observed that the labor of the primiparas is greatly speeded by caudal analgesia.

**Spinal Anesthesia**—In spinal anesthesia, as in caudal the uterine motility is not affected when the anesthesia is below the 11th thoracic segment. Above this level, interference with uterine motility occurs. Also, as in caudal, the spikes of the abdominal muscle contractions of the late second stage in labor are not present, and the abdominal wall appears to have greater relaxation than with caudal. Further observations, however, are needed to confirm the actual picture of uterine motility throughout long continuous spinal labors.

### SUMMARY

The tocograph consists of a simple recording kymograph with which a permanent record of uterine tone frequency rhythm strength and duration of uterine contractions throughout pregnancy and labor can be obtained.

During normal pregnancy, uterine activity increases progressively from the 23rd week, the greatest increase occurring about the 32nd week. Careful study of the prelabor uterine activity makes possible the prediction of the probable course of labor.

The significant factors in the tocograph tracing of normal labor,



- 19 --- The Effect of Estrogenic Substance upon Uterine Motility during Labor Surg, Gynec & Obst., 77 433-434 (Oct ) 1943
- 20 --- The Uterine Contraction Pattern of False Labor and Its Relation to Premature Labor Am J Obst & Gynec., 46 408-411 (Sept ) 1943
- 21 --- The Uterine Contractions Associated with Prolonged Labors Surg Gynec & Obst., 78 207-210 (Feb ) 1944
- 22 --- The Uterine Motility Associated with Posterior Position of the Occiput Am J Obst & Gynec., 47 521-526 (April) 1944
- 23 --- The Role of the Intermittent Contractions of the Uterus in the Process of Labor Am J Obst & Gynec., 49 186-189 (Feb ) 1945
- 24 Frankel, Donald S The Effect of Continuous Caudal Analgesia upon Uterine Motility during Labor Surg., Gynec & Obst., 80 66-68 (Jan ) 1945

## FORCEPS FOR DELIVERY—THEIR USE AND ABUSE

ROBERT M MITCHELL, M D \*

If it were in the power of the *intrapartum fetus* to choose, during the course of labor, whether it would rather be delivered spontaneously or by the aid of the obstetrical forceps, and, did it possess a foreknowledge of the obstetrical abilities of the operator into whose hands its fragile brain had been placed, it is likely that not infrequently a fetal cry or an intelligible *vagus uterinus* would be heard, "Don't put those mutilators on my head, Doctor, I'll run my chance of a normal spontaneous delivery!"

The brutality resulting from abusive use of the obstetrical forceps is deservedly deplorable. Manifestations of this abuse, such as superficial tissue evidences—deep forceps marks in front of the baby's aural canals concomitant with facial paralysis, distorted nose, bruised eye lids, abrasions on the cheeks, lacerations of the scalp, torn ears, deep tissue evidences—the baby's weak whimper, the high-pitched cry ("cerebral cry"), the respiratory faltering, the muscle twitchings, the oculogyric spasms, nystagmus—all results of cerebral center insults, are observed even today, still seen in the finest delivery rooms. The newer obstetrical forceps have made little or no real improvement on basic design or basic principle with respect to protection of the fetal head, maternal pelvis and soft tissues of the birth channel, as exemplified in the still frequent usage of Simpson, Elliott or McLane-Tucker forceps and their axis traction attachments. The principal reason for such calamity still lies, for the most part, in the inadequacies of the operator behind the forceps. It is not ignorance on the part of the operator, but an inability to put into gentle action the knowledge possessed, an inability to bring into clear focus a mind's eye visualization of exactly how the forceps are fitting the fetal head, just where the pressure points in and on the vertex will be when traction is made, and the relation at all times of the maternal pelvic curve to the curves—cephalic and pelvic—of the instrument used.

Innumerable articles, monographs, treatises, and textbooks have been written on the subject of the obstetrical forceps—its origin, its modifications and presentations of new instruments, the indications, contra-indications and complications. It has been called "the greatest boon to the field of obstetrics, it has been declaimed as a murderous instrument and its use advised against, institutions have been known to pride themselves on the low incidence in the use of the obstetrical

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forceps which, in reality, is surely a sense of "false security." Today, there is an almost routine use of "outlet," "low," or prophylactic forceps for delivery of the newborn by the general practitioners and obstetricians. There may be a tendency, in the rush of daily affairs and the taking of much routine for granted, to ignore unconsciously the ever-existent fundamental principles involved in the obstetrical forceps operation. It is not the purpose of this paper to include anything but essentially normal-every-day-variety obstetrics. It is in this great majority of cases that errors in technique occur, evidences of lack of fundamental knowledge crop up. It is the proper understanding, the constant review and reconsideration of fundamentals, their reapplication that results in a better use of the obstetric instrument. The mother and the baby, both of whom are unquestionably grateful, repay the physician by following uneventful postnatal courses.

#### FUNDAMENTAL PRINCIPLES OF OBSTETRICAL FORCEPS

**Know the Instrument.**—Know the obstetrical forceps with which you practice! To be a 'jack' of all forceps and a 'master' of none is obstetrical folly. Familiarity with the fundamental parts or components of one set of obstetrical forceps breeds confidence and automatically familiarizes the operator with other forceps. It is after this initial thorough training with a given set of forceps that a safe trial use of other instruments can be made. The objective is to determine the advantages or disadvantages of each obstetrical forceps with a final preference for a select few.

**DESCRIPTION.**—The obstetrical forceps consists of two parts, a right half and a left half. Each half of the instrument may be described as having a handle, hook or finger rest, lock, shank, blade, tip or apex, front surface and back surface. The *Handle* is to be used only for ease of adjustment and manipulation during application of the instrument. The *Hook* or *Finger Rest*, on each half of the instrument, is to be used only for finger-tip traction or as a point of attachment for axis traction devices. The *Lock* is formed by a crossing of the shanks of the forceps, usually near the junction of handle and shank, and is held in position by opposing shoulders with a flange (English), by means of a screw or pin (French) or a combination of the two principles (German). As a result of the adaptation of the lock, each half of the forceps receives its name. The left half of the forceps is so named since the left blade lies in the left half of the maternal pelvis and the left handle rests in the operator's left hand. So, for the right half of the forceps—the right blade lies in the right half of the maternal pelvis and the right handle rests in the operator's right hand. The lock also influences the method of application of the forceps. The juncture is so fashioned that the left half of the instrument is applied first, and the right half, last. When properly applied the lock falls together effortlessly. However, if the right half of the forceps were to be ap-



plied first and the left half second this would necessitate a recrossing of the handles for assumption of the normal apposition of the lock.

The *Shank* connects the handle to the blade. The shank is of varying length and may be separated from its fellow or approximated by one being placed atop the other. Combined they often serve as a point of attachment for axis traction devices. The point of juncture of the shank with the handle generally entails that portion involved with the lock of the instrument. Each forceps *Blade* has a pelvic curve which lies along the thin edge of the blade and a cephalic curve which lies along the flat surface of the blade. The latter is constructed to fit the head of the fetus, in such a manner that compression of this structure is minimal, and the former, to correspond to the curve of the birth channel to minimize trauma to this passage. The blade of the obstetrical forceps may be fenestrated, nonfenestrated or fenestrated with the pelvic surface closed. The *Tip* or *Apex* of the instrument is simply the distal end of the blade or the opposite end from the handle. The tip points slightly upward from the horizontal in proportion to the degree of pelvic curve. The tips of the forceps do not approximate even with the handles closed. The degree of compression of the fetal head is regulated by the distance between the tips of the blades, or as seen externally when the forceps are in position the space between the handles. The *front* surface of the forceps is the concave aspect of the thin edge of the blade. The *Back* surface of the forceps is the convex aspect of the thin edge of the blade. It is with this knowledge of the front and back of the forceps that another principle of application is derived.

**Know the Function of the Obstetrical Forceps**—The normal attitude of the fetus is one of *universal flexion*. The onset of labor fosters *descent* of the presenting part which in vertex presentations normally results in increased *flexion*. This, in turn, brings the most dependent portion of the vertex, namely, the occiput, in contact with the muscular pelvic floor. The *Law of the Pelvic Floor*, which states that the most dependent portion of the presenting part first striking the pelvic floor will be anteriorly rotated comes into play. This accounts for the next step in the mechanism of labor, that of *Internal Anterior Rotation*. The occiput having been brought into position by these steps becomes impinged beneath the arch of the symphysis pubis and *extension* of the vertex takes place. With each succeeding voluntary muscular exertion and involuntary muscular force of labor, extension increases aided by resistance of the perineal floor. Thus the presenting part tends to proceed along the line of least resistance—the birth channel—following the *Curve of Carus* and guided by the pelvic and perineal muscle bodies. It is this portion of the mechanism of labor that the obstetrical forceps were designed to aid, designed to be applied to the sides of the baby's head and to fit the contour of the maternal pelvis. Hence, the forceps permit intercession at some indi-

carated point along the delivery path, coincident with the normal mechanisms of labor, from that point on to completion of extraction of the living fetus. The purpose is to effect less trauma to fetal and maternal parts than would have been suffered had a spontaneous delivery terminated the second stage of labor.

*Traction*, then, becomes the *primary function* of the obstetrical forceps. To know how much traction is necessary, to know the directions in which traction should be made, to properly gauge intervals of traction and relaxation, to recognize abnormalities or resistance offered by the advancing presenting part and of the maternal soft tissues are requisites for the intelligent operation of the instrument.

The subsidiary functions of the instrument—rotation, leverage, compression and dilatation—are to be used only in discreet instances by the accomplished operator. The second most common function, then—*Rotation*—must be cautiously performed. The maternal soft parts—bladder, vaginal walls, cervix, lower uterine segment and perineal body—can all be seriously injured, the operator oblivious to this damage until postdelivery inspection reveals the destruction.

*Leverage* is an inherent function of the forceps. The only proper place forceps can be used as levers or copy a pendulum motion is when the vertex has passed the bony pelvic outlet.

*Compression* is an intrinsic function impossible to avoid. Traction with the forceps automatically compresses the vertex, resistance of the bony pelvis and soft tissues automatically compresses the vertex, each uterine contraction forcing the vertex deeper into this pit of resistance compresses the head, but, the proper application of the forceps and controlled traction aided by episiotomy or perineotomy reduces, pronouncedly, possible postdelivery manifestations of deep and superficial tissue insults. *More fetal embarrassment results from abnormal compression of the vertex than from any other function of forceps.* Fear of excessive compression is the undercurrent phantom that stalks all forceps deliveries.

*Dilatation* of an undilated cervix by the obstetrical forceps or the dragging of a fetal head through an undilated cervix by the obstetrical forceps is a function of the forceps mentioned only to be condemned. This is pure ignorance and only leads the operator deeper and deeper into the depths of obstetrical morbidity and mortality.

Know the Classical Applications of the Obstetrical Forceps—The *cephalic* curve and the *pelvic* curve of the obstetrical forceps determine the three possible forceps applications, namely, cephalic, pelvic and cephalopelvic.

The teaching of the oldsters, that the *cephalic* application is the best, is as true today as it has always been. The adjustment of the cephalic curve of the forceps to fit the cephalic curve of the fetus, regardless of the relation of the pelvic curve of the forceps to that of the pelvis, reduces injury to the vertex.

To make a *pelvic* application of the forceps *i.e.*, to adapt the pelvic curve of the instrument to the maternal pelvic curve, regardless of the position of the fetal head, encourages abnormal stress and strain in and on the delicate vertex. This application, with the unavoidable increased traction needed for delivery, is far from being the preferred method. The *cephalopelvic* adaptation of the forceps is the ideal prehension to be pursued. When the curves of the obstetric instrument conform to the fetal vertex and the maternal pelvis, the contingency of abuse may be curtailed. The cephalic application and the cephalopelvic application of the blades are the attempts of the operator to coincide with the existent step in the mechanism of labor and to offer at that opportune moment harmless, mechanical intervention for termination of labor.

**Know the Principles of Application of the Obstetrical Forceps**—The secret of intelligent handling of obstetrical forceps lies in the comprehension of two fundamental principles of application. The first is known as the *Law of the Forceps* and the second is known as the *Rule of the Forceps*. These two fundamental principles permit even the novice to appear capable of safely conducting the first step of a simple outlet forceps operation. The operator must visualize how the forceps are to be held, *i.e.*, how they will lie when in position, in relation to the fetal head and maternal pelvis. This is done by first demonstrating externally the intended position of the instrument and constitutes the Law of the Forceps.

The *Law of the Forceps* states that the front of the forceps must face the point of direction. The point of direction is that arbitrary point on the baby's head that is rotating internally and anteriorly to impinge beneath the symphysis pubis. In occiput anterior positions it is the occiput. In occiput posterior positions, it is the forehead, and the moment the occiput has rotated from a posterior position to a transverse position it again becomes the point of direction. The plane of the forceps is said to lie in any given diameter of the pelvis when the line passing through the center of the flat surface of the blades of the instrument lies in any given diameter of the pelvis. The fetal vertex is said to lie in any given diameter of the pelvis when the sagittal suture lies in any given diameter of the pelvis. In the cephalopelvic application for occiput anterior position, the sagittal suture of the fetal vertex lies in the anteroposterior diameter of the pelvis and the plane of the forceps is said to lie in the transverse diameter of the pelvis. Hence, the front of the forceps faces the occiput or lies at a right angle to the sagittal suture. In any of the cephalic applications the front of the forceps faces the point of direction and the plane of the forceps lies at a right angle to the sagittal suture. There are *no exceptions* to the Law of the Forceps.

The *Rule of the Forceps* indicates how each blade is to be applied. It, too, is derived from the construction of the obstetrical forceps.

The lock is so arranged and the handles crossed in such a fashion that a principle of application evolves. It states that with the left handle of the forceps held in the left hand, the left blade is introduced into the left half of the maternal pelvis, the right handle of the forceps held in the right hand introduces the right blade into the right half of the maternal pelvis. The Rule of the Forceps is without exception in all occiput anterior and occiput posterior positions. The application of the forceps in the transverse occiput positions follows the Rule of the Forceps except when the occiput is right transverse. It is in this instance that the right blade is introduced first, the left blade second. The handles must be recrossed to lock. The point to remember, in relation to transverse occiput positions, is that *the bottom blade of the forceps is applied first*.

Know the Indications for Obstetrical Forceps—To recognize when forceps should be applied revolves about the general condition of the mother and the baby. To waylay intervention or inaugurate it prematurely is not "prudent prolepsis."

The most common *maternal indication* is "insufficiency of the powers of labor" to effect delivery, once the presenting part has reached the perineum. This may result from a decrease in intensity of uterine contractions, a too rigid perineum, a large baby, maternal exhaustion—physically and nervously—and with the now frequently used regional anesthetics, which take the "push" out of the second stage of labor. The patient should be permitted to demonstrate the proficiency of her labor but not allowed to demonstrate her ability to absorb the abuse of a prolonged labor. The failure of complete anterior rotation of the vertex is a second common indication for forceps. Occiput posteriors are the most frequent offenders and the failure of rotation usually results in the "deep transverse arrest." Persistent occiput posterior positions are not infrequently encountered. The manipulation of the vertex from this position, with the obstetrical forceps, requires no little ability. Forceps are indicated to relieve excessive strain on the uterine scar during the second stage of labor of a previously cesareanized patient. General conditions which complicate the antepartum and intrapartum states primarily affecting the mother, but secondarily the baby, justify the aid of obstetrical forceps. Toxemias of pregnancy, such as severe preeclampsia or a "full blown" eclampsia, acute or chronic diseases of lungs, heart and kidneys—pulmonary tuberculosis, rheumatic heart disease, nephritis, hernia, partial abruptio placentae, and a low-lying or a marginal placenta praevia are such examples.

The most common *fetal indication* is evidence of intrauterine fetal distress or threatened fetal asphyxia. This distress becomes apparent in alteration of the fetal heart rate (irregularity—not at the time of a labor pain) (normal variation from 100 to 180 per minute), appearance of meconium stained amniotic fluid in vertex presentations, or

rumultuous fetal movements in utero The maternal conditions mentioned above, prematurity, prolapse of the umbilical cord, fetal malpresentations as brow, face, or transverse lie, drops in maternal blood pressure—prolonged—occasionally accompanying regional anesthesia are contributing causes of intrauterine asphyxia Interference, by aid of the obstetrical forceps, is indicated in these maternal or fetal conditions provided their use accomplishes the purpose without undue damage to either the parturient or the fetus To attempt vaginal delivery with forceps through an unfavorable cervix is misguided intrepidity When the cervix is completely dilated and effaced and the head has advanced to and remained on the perineum for one hour, or when, after complete cervical dilatation for two hours the vertex fails to advance beyond (e.g., a deep transverse arrest, the maternal and fetal status not indicating earlier delivery), the operator has an absolute indication for prophylactic interference with the obstetrical forceps Control by forceps of the after coming head in breech deliveries supplants ungoverned suprapubic pressure and frantic attempts at manual extraction Control by forceps of vertex deliveries in the laparotrachelotomy displaces vigorous manipulative extraction

**Know the Conditions for Obstetrical Forceps**—Fulfillment of the obstetrical obligations must be concluded prior to any attempt at forceps delivery *Surgical asepsis* of the delivery field is essential Today, postpartum morbidity from endometritis or puerperal infection originating from an improperly antiseptized vulva rarely occurs Tincture of green soap, sterile distilled water, and a 1 per cent solution of lysol may be used freely in scrubbing the pudendum, lower abdomen and thighs

**Empty the urinary bladder** The deliverance of a patient with a partially filled or distended bladder is thoughtless Vaginal delivery, whether spontaneous or by forceps, is impossible to conduct without producing some degree of bladder trauma Empty the bladder in the attempt to minimize injury, decrease the incidence of postpartum catheterization and postnatal anterior vaginal wall relaxation Remember, when an obstruction is met, in catheterizing a parturient, the vertex is most likely impinged beneath the symphysis *Don't force the catheter into the bladder by brute force* but, instead introduce two fingers into the vagina and dislodge the vertex by gentle subopercular pressure

**Empty the rectum** In most instances, the patient receives a cleansing enema on admission to the hospital and the lower bowel remains empty throughout labor and delivery A fecal impaction in the rectum can sometimes prevent descent of the presenting part to the perineum *A full rectum is a constant source of contamination* A steady stream of feces is discharged throughout delivery and the operator must be on the alert to avoid soil to himself and the operative field If a regional anesthesia is used for labor and delivery, it is most pertinent

that the enema be thoroughly expelled prior to establishment of analgesia. *Loss of anal sphincter tone and incompletely expelled enema are not conducive to cleanliness of the operative field.*

*Position of the fetal vertex* must be known. First by vaginal examination, identify the fontanelle (suture line combination) which lies beneath the symphysis. When the vertex is on the perineum the fontanelle which lies anterior does not lie behind the symphysis but is readily found just inside the introitus well below the symphysis. Secondly, identify the sagittal suture and determine the oblique diameter of the pelvic outlet in which it lies. Thirdly, check the fontanelle (suture line combination), which lies posterior. This is easily accomplished by introducing four fingers, palmar surface toward the vertex into the vaginal canal. Making gentle pressure on the perineum the fingers can be introduced far up beneath the head without fear of dislodging it. The external hand makes sufficient fundal pressure to maintain the fetal head in place. The landmark is readily identified by sweeping the vaginal fingers from side to side. The long middle finger of the examining hand falls into whichever fontanelle lies posterior and the suture line combination is distinguished. If these attempts have proved unsuccessful, the hand is slipped up alongside the head and the external ear is palpated. The tragus points to the face. If the ear lies in the hollow of the sacrum, the position of the vertex is transverse.

*Complete effacement and dilatation of the cervix* must be assured. Vaginal examination will readily determine this condition. Occasionally, a thick, edematous, persistent anterior lip of cervix is discovered. It results from the anterior lip of the cervix being trapped between the symphysis and the vertex during the course of labor. It may be remedied by dislodging the cervix, pushing it back over the occiput up behind the symphysis. Occasionally a cervix becomes completely dilated but fails to retract over the vertex. This condition is readily corrected by simply pushing the cervix back over the vertex out of the way of the forceps. Failure of the operator to recognize and respect this one condition has resulted in more instances of "failed forceps" than any other factor. "Watchful waiting," masterful inactivity," and "scientific neglect" describe the ministrations of the accoucheur while this condition for forceps is fulfilled.

*The bag of waters must be ruptured.* The failure of the bag of waters to rupture not infrequently prevents the presenting part from reaching the perineum or the lowest point to which it would have advanced prior to interference. Vaginal examination readily determines the rupture of the forewater. If the membranes are found intact, they are ruptured and stripped away from the vertex. It is not a wise policy to apply the forceps extraovularly, i.e., to the vertex enclosed in the membranes, first, because the slippery, smooth gestational sac contributes to slipping of the instrument, and secondly, the

placental site may be partially disrupted, with ensuing fetal distress from the tug on the tough amnion and chorion caught between the vertex and the forceps.

*Cephalopelvic disproportion* must be absent. To attempt vaginal delivery when a disproportion between passenger and passage exists creates irrevocable havoc. Comprehensive prenatal examination or, as term approaches, roentgenologic pelvimetry aids in preventing such occurrences. However, a trial of labor may be necessary to demonstrate conclusively, in borderline cases, a cephalopelvic disproportion.

*The baby must be alive.* The application of forceps to the vertex of a fetus that expired in utero and has become macerated, with the head a "bag of bones," is unsatisfactory. The forceps may slip off the vertex because of improper fit, also, too strenuous traction may sever the fetal head from the fetal corpus. Stillbirths of recent origin, developing during the course of the average length labor, offer no such forceps difficulty.

*The station of the vertex* must be known. The station of the fetal head denotes progress of descent. DeLee's method of referring to station as a plus or minus quantity in relation to the ischial spines is one with which it is good to be familiar. The ischial spines are designated as station 0. One centimeter above the spines (estimated by rectal or sterile vaginal examination) is said to be station -1. Likewise, 1 cm below the ischial spines is said to be station +1. Station -5 is the plane of the pelvic inlet and station +5 is the plane of the pelvic outlet. The vertex is floating at station -5, engaged when the lowest part of the bony vertex is at station 0, and is on the perineum when the advancing bony skull is at station +5.

*Discourage repetitious vaginal examinations.* "Get in and get out" is a sound dictum for the chances of postpartum morbidity increase with each succeeding vaginal manipulation. Once the fingers or hand have been introduced into the vagina, gain as much information as possible from the initial examination. Rupture of the membranes, position of the fetal head, station of the vertex and cervical dilatation and effacement are conditions to be learned by this initial vaginal examination. *During all manipulations the operator must keep the examining fingers away from the region of the anus.*

#### FORCEPS FOR DELIVERY

Forceps operations are designated after the plane in which the operation is performed, i.e., "outlet forceps"—plane of the outlet, "midforceps"—midpelvic plane or plane of the ischial spines, "high forceps"—plane of the inlet. The respective stations of the vertex are +5, 0, -5. Let it be understood, however, that from station -5 to 0 forceps applications are still "high forceps" applications, that from station 0 to +5, forceps applications are "midforceps" applications, and that, from station +5 until the vertex has delivered over the

perineum forceps applications are of the true outlet forceps category

## OUTLET FORCEPS OPERATION

### OBSTETRICAL FORCEPS

McLane Tucker forceps or Luikart modification of McLane Tucker forceps preferred

### INDICATION

Present

### CONDITIONS

Fulfilled station +5 or crowning position O A

### APPLICATION

Demonstrate Law of Forceps

Apply Rule of Forceps—cephalopelvic application

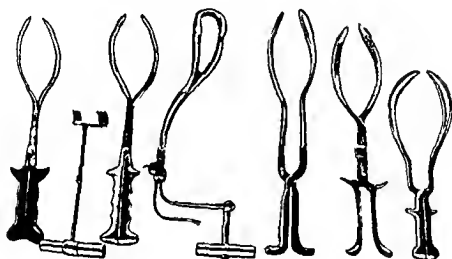


Fig 526—Photograph of obstetrical forceps routinely used at the Lying In Division of the Pennsylvania Hospital Reading from left to right McLane forceps Bill axis traction bar Luikart modification of McLane Tucker forceps Piper axis traction forceps Piper after-coming head forceps Luikart modification of Kielland forceps and DeLee cesarean section forceps

Check application (1) palpate sagittal suture—see that it lies equidistant from each blade (2) palpate two fingerbreadths space between occiput and juncture of blade with shank of forceps and (3) palpate proximal portion of fenestration of blade that lies alongside edge of occipital bone

### LOCKING THE FORCEPS

Blades properly applied when lock falls together automatically

Bring lock into apposition by slight depression of handles to aid rotation of blades into pelvic and cephalic curves

### EXTRACTION

A true outlet forceps delivery (occiput impinged beneath symphysis)

Make trial traction to see forceps do not slip

Complete delivery by extension of vertex



Make traction along line of *resultant force* of upward and outward force, represented in diagram



Make finger-tip traction on finger rests or hooks (all force needed)

*Do not grab handles and compress*

How much traction should be made—variable

*Amount of traction needed decreases with increase in operator's skill*

**Rules for Traction:** (1) Make traction without bracing feet against delivery table, (2) make traction with only biceps muscles of arm, (3) make traction without dragging patient's buttocks towards or off end of delivery table, and (4) recheck position of vertex and application of forceps if vertex does not advance with ease

Save perineal body and decrease compression of fetal vertex by perineotomy or episiotomy, perform perineotomy or episiotomy during period of ex-

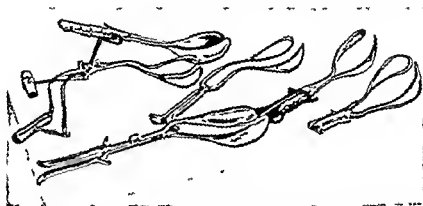


Fig 527—Photograph of the obstetrical forceps shown in Figure 526 but from an oblique angle to demonstrate more clearly the contours of these instruments. The Bill axis traction bar is attached to the Lusk modified McLane-Tucker forceps

tension of fetal head, i.e., during period of perineal body dilation place perineum on stretch by vertex, make incision and evaluate depth to which incision should be carried now, select episiotomy if antero-posterior diameter of perineum is too shallow and there is fear of third degree laceration.

Use Bill traction bar rarely for this type of delivery

#### REMOVING THE FORCEPS

Deliver forceps with fetal head or remove forceps before delivery complete to diminish diameter of presenting part

Deliver vertex with modified Ritgen's maneuver

Remove forceps in opposite manner to which they are applied—right blade first, left blade second (follow same arcs of application but in reverse)

#### "LOW FORCEPS" or "LOW MIDFORCEPS" OPERATION

##### OBSTETRICAL FORCEPS

Lusk modification of McLane-Tucker forceps with Bill traction bar at attachment preferred

## INDICATION

Present

## CONDITIONS

Fulfilled station +3 to +5 position O L A or O R A

## APPLICATION

Demonstrate Law of Forceps

Apply Rule of Forceps

Complete cephalic application with ease

Readjust or remove and reapply forceps if necessary (*Do not force blades into position*)

Check application as described above

## LOCKING THE FORCEPS

Blades properly applied when forceps lock easily

## EXTRACTION

Make trial traction

Rotate occiput gently to O A as traction is made

Impinge occiput beneath symphysis by traction in direction of resultant of two forces downward force and outward force



Pull in proper direction by Bill axis traction bar attached to hooks of forceps (traction made in line with plane of pelvic inlet)

Change direction of traction anticipate extension of vertex following impingement of occiput

Complete delivery as described under outlet forceps operation

## REMOVING THE FORCEPS

Remove forceps as described under outlet forceps operation

## MIDFORCEPS OPERATION

## OBSTETRICAL FORCEPS

Piper axis traction forceps Luskart modification of McLane Tucker forceps with Bill axis traction bar Luskart modification of Kielland forceps with traction attachment

## INDICATIONS

Present

## CONDITIONS

Fulfilled station 0 to +3 position (O R T or O L T) deep transverse arrest

## APPLICATION

Demonstrate Law of Forceps

Most frequently encountered position of vertex in midpelvis is occiput transverse

Apply Rule of Forceps

A Routine transverse forceps application

1 Apply bottom blade blade shoved under vertex tip of forceps rests on sacral promontory cephalic curve of blade lies in contact with cephalic curve of fetal head

(a) Apply bottom blade of forceps (left) first if position O L T (*Here Rule of Forceps holds true*)(b) Apply bottom blade of forceps (right) first if position O R T (*Exception to Rule of Forceps exists here—handles must be recrossed to lock*)

2 Wander top blade (with vaginal fingers) past chin over face to position between vertex and symphysis pubis cephalic curve

of blade faces cephalic curve of fetal vertex this constitutes cephalic application in both positions O L T and O R T (top blade called *wandering blade*)

- 3 Insure proper adjustment by gentle manipulation plus mental picture of curves of instrument and their relationship to fetal vertex and pelvis

#### B Aids in application

- 1 *One Blade Rotation* Introduce bottom blade encourage patient to bear down and at same instant attempt to gently rotate vertex into one or other oblique then apply other half of forceps
- 2 *Manual Rotation* This may become a *high forceps application*
  - (a) If O R T introduce left hand into vagina place four fingers beneath head thumb on upper surface dislodge vertex slightly upward and at same instant gently rotate fetal occiput into left oblique (45 degrees) or into right oblique (135 degrees), apply forceps as head is maintained in position
  - (b) If O L T introduce right hand into vagina fetal head rotated into right oblique or left oblique

#### LOCKING THE FORCEPS

Do not force lock plane of forceps is in unfavorable anteroposterior diameter of pelvis (blades may not lock until rotation starts)

Bring lock together as plane of forceps comes into this or that oblique

Carefully readjust forceps and try to lock again if blades have slipped out of position on fetal head during attempt to approximate lock

#### EXTRACTION

Attach Bill axis traction bar to hooks of forceps

Gently rotate vertex by combination *push turn pull* or *pull pull turn* type of force *do not churn fetal head in pelvis*

Determine direction in which vertex seems to move with least amount of traction gradually complete rotation at same time that traction is being made on axis traction attachments *line of traction is in line with plane of pelvic inlet*

Complete delivery by extension of vertex once occiput has impinged beneath pubic arch

Remember traction on forceps increases compression of fetal vertex

*Rules for Traction* (1) make traction in sequence resembling labor (2) make traction by gradually increasing force advancing fetal vertex no more than one centimeter with each effort (3) release traction force gradually, allowing fetal head to slip back if it desires to its original position (4) wait traction interval of one to two minutes for reestablishment of circulation in fetal cranial *caule* (5) *do not drag fetal head out and over perineum with one fell swoop of instrument* (6) *do not compress handles of forceps*

#### REMOVING THE FORCEPS

Perform in usual fashion described above

Remove Bill traction bar as extension of vertex progresses

### MANAGEMENT OF POSTERIOR OCCIPUT POSITION

#### OBSTETRICAL FORCEPS

McLane Tucker forceps Luskart modification of McLane Tucker forceps,  
Piper axis traction forceps or Luskart modification of Kielland forceps

#### INDICATION

Present

## CONDITIONS

Fulfilled, station —3, position O-R-P, O-L-P or O-P.

## APPLICATION

Demonstrate Law of Forceps.

Apply Rule of Forceps.

Check position of forceps.

## LOCKING THE FORCEPS

See described above.

## EXTRACTION

Variation in pelvic curve or forceps influences size of arc traversed by handles to complete rotation.

*Scissors Manuever—Rotation of Posterior Occiput on Perineum;* McLane-Tucker forceps or Luskart modification of McLane-Tucker forceps preferred.

Flex vertex by lifting handles upward or toward either inguinal area. Voluntary effort or "bearing down" of patient aids rotation.

Maintain tips of instrument at fixed point while handles of instrument are rotated slowly, carefully through wide arc.

Examine bladder, urethra, vaginal walls and perineum periodically during this maneuver to insure against injury as edema and external surfaces of blades come in contact with them.

*Do not force rotation; gently rotate by push-turn-pull type of manipulation to find line of least resistance.*

Once rotation of occiput starts it will proceed with very little force on part of operator.

Forceps are upside down as occiput rotates into one of anterior positions.

Remove forceps in upside down position for reapplication to O-L-A, O-R-A or O-A position, perineotomy or episiotomy may permit delivery without reapplication of forceps.

*Bill Manuever—Rotation of Posterior Occiput in Midpelvis;* Luskart modification of McLane-Tucker forceps, Piper axis traction forceps or Luskart modification or Kielland forceps preferred.

Follow steps of application, find favorable pelvic plane for entering by push-turn-pull mechanism, rotate by carrying handles through same wide arc, check by palpation for evidence of soft tissue strain, complete rotation.

Remove blades upside down and reapply as for anterior occiput position.

Complete delivery as described under "midforceps" operation.

*Manual Rotation—Manual Rotation of Posterior Occiput at Plane of Pelvic Inlet;* Piper axis traction forceps preferred for delivery.

Use left hand for O-R-P, use right hand for O-L-P.

Place gentle upward pressure on vertex.

Dislodge vertex to plane of pelvic inlet.

Rotate vertex and shoulders through 180 degree arc.

Flex head and allow it to follow hand down into midpelvis.

Apply forceps as for "midforceps" or even "high forceps" and complete delivery as described above.

*Alternative Method—Forceps Delivery of Posterior Occiput at Sacral Plane of Pelvic Outlet;* Luskart modification of McLane-Tucker forceps with Bill axis traction bar preferred.

Permit vertex to deliver as persistent occiput posterior.

Apply forceps as for occiput anterior position.

Perform wide episiotomy.

Make traction downward and outward to impinge forehead beneath pubic arch

Deliver vertex by *flexion*

#### REMOVING THE FORCEPS

Described above

### MANAGEMENT OF AFTER COMING HEAD IN BREECH PRESENTATIONS

#### OBSTETRICAL FORCEPS

Piper forceps for after coming head preferred

#### INDICATIONS

*Present*

#### CONDITIONS

Fulfilled station—vertex in true pelvis

#### APPLICATION

Assistant holds body of baby outward and slightly upward out of way of operator

Apply forceps as for O A position

Demonstrate Law of Forceps

Apply Rule of Forceps—best done with operator down on one knee

Make cephalopelvic application

#### LOCKING THE FORCEPS

Complete with ease by slight depression of handles

#### EXTRACTION

Make traction in similar manner described under low forceps operation

Raise handles slowly upward

Deliver head by *flexion*

Cleanse and keep open air passages of baby

Proceed with delivery calmly and slowly to prevent sudden decompression of vertex

Perform *perineotomy* or *episiotomy* prior to forceps application

#### REMOVING THE FORCEPS

Head usually born with forceps still in place

### MANAGEMENT OF VERTEX PRESENTATION IN CESAREAN SECTION

#### OBSTETRICAL FORCEPS

Small DeLee cesarean section forceps preferred

#### INDICATIONS

*Present*

#### CONDITIONS

Fulfilled

#### APPLICATION

Demonstrate Law of Forceps

Apply Rule of Forceps

Manually rotate vertex so that occiput or face appears through incision

Make cephalic application

#### LOCKING THE FORCEPS

Forceps properly applied *lock with ease*

#### EXTRACTION

Complete by gentle traction (*flexion* or *extension*)

#### REMOVING THE FORCEPS

Blades deliver with vertex

## HIGH FORCEPS' OPERATION

## OBSTETRICAL FORCEPS

Piper axis traction forceps preferred

## INDICATIONS

Present

## CONDITIONS

Fulfilled station —5 to 0 (station acquired through effect of labor or through intervention of operator)

## APPLICATION

Demonstrate Law of Forceps

Apply Rule of Forceps

Check position of forceps by palpation

## LOCKING THE FORCEPS

Described under midforceps operation

## EXTRACTION

Described under 'midforceps' operation

## REMOVING THE FORCEPS

Described above

## CAUTIONS

*Trial by forceps operation in cases of cephalopelvic disproportion has been replaced, for the most part, by cesarean section*

*Forceps on the floating head is an operation mentioned only to be condemned*  
*"Midforceps" operation and "high forceps" operation are procedures not to be undertaken by the tyro*

## THE WATERS OPERATION IN MODERN OBSTETRICS

CLARENCE C. BRISCOE, M.D.\*

Nor so many months ago a patient was admitted to the wards of one of our larger hospitals upon whom, after twenty-four hours of labor and numerous unsterile vaginal examinations, an unsuccessful version and high forceps delivery had been attempted in the office of a practitioner. The bladder was ruptured, there was a complete perineal tear, the cervix was lacerated but undilated and there was a brow presentation. After repair of the damage and treatment of shock this nulliparous patient was delivered by a Waters extraperitoneal cesarean section. No peritonitis developed and the patient still has her uterus to try again—in better hands, it is hoped. This is a dramatic case but, sad to relate, not unusual. The report of such bungling obstetrics immediately calls forth the response that this is an isolated instance and that it does not happen in "our" institution nor in "our" practice. Yet this practice was within the shadows of an excellent maternity hospital and in a city supporting five medical schools. For those of a skeptical nature there is proof abundant that postcesarean sepsis is still a major cause of maternal mortality.

No one will deny that cesarean section contributes largely to maternal mortality, carrying, as it does in most clinics, a death rate of one to three per cent. In the past two years over 5000 cesarean sections were reported in the *American Journal of Obstetrics and Gynecology*. One third of the reported deaths were caused by sepsis. The same results were found in Philadelphia in our recent survey, and sepsis, so far as section is concerned, is practically synonymous with peritonitis. A personal detailed review of forty-five autopsies showed that 80 per cent of these patients died of generalized peritonitis. Furthermore, the details helped establish the modus operandi of this pathological process. Following incision into an infected uterus there is spread of suppuration from the endometrium through the uterine suture line resulting in infectious spill into the peritoneal cavity. If the incision is in the fundus, muscular activity favors spread of infective material. When the incision is below a peritoneal flap, suppuration may collect beneath this flap and eventually break through into the peritoneal cavity. In neither instance is spill of infected material prevented at the time of operation. In contrast, it should be remembered that an extraperitoneal section prevents original spill and establishes drainage extraperitoneally should the suture line break down.

Now, of course, in the experience of any good obstetrician the num-

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ber of deaths from postcesarean peritonitis does not seem large. He is a busy man who performs fifty cesareans a year. That means two years before there is a mortality or probably six years before there is a mortality from sepsis. If he is fortunate, he will perhaps miss one septic case so that twelve years have passed since his last patient died of peritonitis. Beyond twelve years the memory is dim but we can not escape the established fact that sepsis is responsible for one out of every three cesarean fatalities and it should be fairly evident that *someone* was the operator in these incidences. A leading protagonist of the classical operation has reported that 4 per cent of the cesareans performed in Philadelphia are actually or potentially infected. In numbers this means approximately forty patients a year risk death from peritonitis and three or four of these forty actually die for we have found that nearly 40 per cent of the women who die of supuration following sections come from this neglected group. It should be fairly evident, therefore, that peritonitis still kills, despite sulfonamides and penicillin, it still kills.

Any method of preventing peritonitis in definitely infected patients or in the suspicious ones therefore, must appeal to our good judgment, provided it can be performed with safety, reasonable speed and without too much technical difficulty. Such a procedure is the Waters suprapubic extraperitoneal operation, a major technical advance in the history of cesarean section.

### TECHNIC

Following are the essential steps of the Waters technic. More complete details may be found in Waters' original presentation in the *American Journal of Obstetrics and Gynecology* for March 1940 and for June 1945.

Blood is available and an infusion is started as soon as the patient reaches the operating room. The anesthesia of choice is continuous spinal given in fractional doses of 25 mg. of procaine or 15 mg. of metycaine. The blood pressure is stabilized before starting. The bladder is filled with water (which may be colored with methylene blue although this is unnecessary) until it can be visualized above the symphysis. It must not be overdistended and there must be no air bubbles in the system which is arranged so that the bladder may be emptied and refilled at will. A fairly large catheter is helpful. The skin incision is made far enough away from the midline to come down over the belly of the rectus muscle, thus preventing direct incision of the peritoneum. Next the rectus and transversalis fascia are incised and separated laterally so that the distended bladder presents itself (Figs 528 to 533). \* Below the fundus of the bladder the laminated peri-

\* We wish to express our deep appreciation to Dr. Edward G. Waters for his kindness in permitting reproduction of these photographs and legends.





Fig 528—Trap door approach freeing and retracting rectus muscle laterally. The distended bladder is shown through the overlying perivesical fascia and transversalis fascia. The transversalis fascia has been partly incised over the lower part of the bladder.



Fig 529—T shaped incision in perivesical fascia has been made. Fascia separated laterally and over the top of bladder fundus. The bladder is shown distended and colored with methylene blue solution. The vesical vessels lying on the bladder muscularis identify the plane of separation from the laminated perivesical fascia.

vesical fascia itself is incised until one can clearly see the small vessels lying on the bladder musculature. The knife handle is inserted bilaterally and cephalad until this fascia is well separated from the bladder. Posteriorly, on the left, the bladder fascia again must be incised as it passes down between the bladder and the lower uterine segment. Thus a 'skullcap' of fascia to which the peritoneum is attached is freed from the bladder fundus to the uterovesical peritoneal pouch. The emptied bladder then being freed of all fascia to which peritoneum is attached is dropped below the symphysis. Then the peritoneum and fascial cap can be pushed off the lower uterine seg-

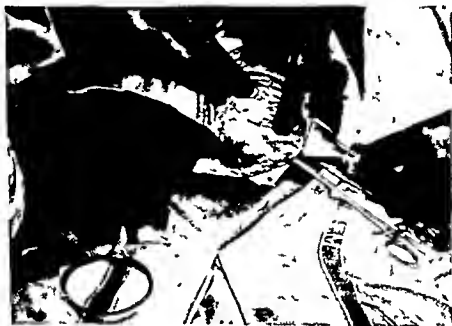


Fig. 530—The collapsed bladder is dropped downward and perivesical fascia with peritoneum drawn upward until the hernia like sac of the peritoneal uterovesical plica is seen as indicated by the finger. The finger rests on the plica while a small section of the lower anterior portion of the uterus is seen between it and the partially collapsed bladder. Beginning here incision in the vesical fascia and periuterine fascia is made.

ment as far as necessary for wide exposure and the rest of the procedure follows that of the Kerr operation. When closing the uterus it is important to invert the first suture layer with a continuous Cushing stitch. Also it is a wise precaution to incise the lower uterine segment at least an inch above the bladder attachment otherwise the suture line comes very close to the bladder after the uterus has contracted. Bleeding is controlled, 'sulfa' powder is dusted in, a soft drain is inserted and after dropping the peritoneofascial cap back into place the abdomen is closed.

That this technic is not too difficult has been shown by its



Fig. 531—The finger is passed behind the vesical and uterine fascia bluntly and easily separating the bladder from the lower uterine segment. Then the finger is passed beneath the uterovesical peritoneal fold lifting it upward. Sharp knife dissection is carried between the fold and the bladder, cutting the posterior portion of the perivesical fascia. The bladder is seen being held down the plica lifted up while in the depth is seen the lower uterine surface.

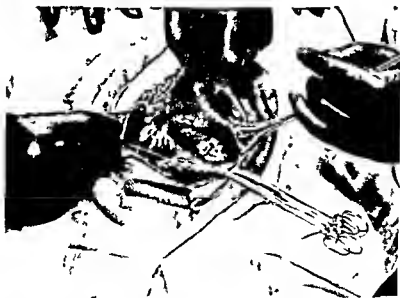


Fig. 532—Further dissection of the peritoneofascial fold from the bladder. The bladder is indicated as being held downward with the knife handle. The fingers hold up the peritoneofascial fold. The retractor is placed to demonstrate the ever enlarging area of lower uterine segment.

spread adoption and by our own experience. During the past four years we have instructed eight different operators (six were residents) who performed their first operation within an hour and only one injured the peritoneum. We have had occasion to use this procedure thirty times in six different hospitals during the past six years. The bladder was injured once and the peritoneum opened five times. *It must be clearly understood that opening the peritoneum before incising the uterus does not detract from the protection of the operation for once this opening is tied off spill is prevented and the peritoneum*



Fig 533—Four retractors placed, one holding bladder down, one holding peritoneofascial fold upward and two placed laterally for ample exposure. The entire area seen here is the retroperitoneal portion of the lower anterior segment of the uterus. The site of the uterine incision is indicated by the initial central nick. From this point a curved crescentic incision with apex downward is carried laterally in either direction. The size of the baby's head determines to a certain degree the acuteness of the curve. The ends avoid the broad ligament vessels. The knife blade must be held at right angles to the uterine muscle surface curve.

*completely seals itself.* After a little experience the procedure should not take more than thirty or forty minutes to perform. It is a meticulous, gentle operation but not too difficult for the trained operator. The technic can be mastered by observation and application in a few practice cases which are not infected. Certainly one member of each hospital staff should be able to perform this section with facility. Waters has reported two hundred and fifty cases with a mortality rate of less than 1 per cent.

The uterus is saved, itself an important factor since so much

lected dystocia is seen in the nulliparas, but in addition we have shown that the results are superior to those of the Porro operation. Since we can save women from peritonitis who are definitely infected, should we not extend the indications for this operation to the merely suspicious cases? Certainly any woman who has had vaginal manipulation labor for twenty-four hours, or labor of any length plus an elevated temperature should have the added protection of this antiseptical approach.

## EXTERNAL VERSION

CARL E. WOLFRON, M.D.

THE changing of one presentation or pole of the fetal ellipse for another is known as version. This changing or turning about has been occurring since the beginning of time without the aid of man, depending on the motive powers of the fetus together with the position of the mother. Version may be classified according to the method used in substituting one presenting part for another, being called internal, external and combined. Before the sixteenth century, when internal podalic version was introduced, external or cephalic version was the only type performed. Cephalic version is one of the oldest obstetrical operations. It is the simplest form of version and is said to have been recommended by Hippocrates. The ancients believed that the fetus was born by its own power, forcing itself through the birth canal by foot and leg action against the fundus uteri. They thought breech presentation impossible of delivery and therefore practiced external, and later, internal cephalic version. This practice was followed from antiquity to the time of Ambroise Pare (1510-1590), in the sixteenth century Pare reintroduced and popularized internal version and thus forced external version into the background, where it remained until Wigand (1807) revived the practice. It has been used rather sporadically to the present time, the Pinard (1889) method being mostly followed. With the ease of podalic version, the advances in the technic of cesarean section, and the after-coming-head forceps, external version has been largely discontinued.

Due to the conceded high fetal mortality incident to breech deliveries, it is felt worthwhile to adopt external version in breech presentations during antepartum care, and thus appreciably lower the fetal mortality rate. Siegel and McNally<sup>1</sup> reduced the fetal mortality rate from 45 to 3 per cent. Chamanalal Melita lowered it from 37.5 to 4.5 per cent (with no mortality in versioned cases). George H. Ryder,<sup>2</sup> in reporting 1700 personal cases in which version was attempted 214 times, had no fetal mortality incident to version and reported success in 92.5 per cent of his cases.

External version is the safest way of converting unfavorable presentations. It is little appreciated that the procedure properly carried out is practically devoid of danger. Often it is easily accomplished. Operative incidence is markedly lowered by conversion to head presentation, thus fetal and maternal mortality and morbidity are greatly lessened. Labors are shorter and easier, with less fetal hazard. One

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great advantage is that the borderline pelvis can more accurately be estimated for actual disproportion, this being easier in cephalic than in breech presentations. Premature labor is less likely in vertex presentation than in breech, as also is prolapsed cord.

For those opposing the internal procedure of version, the opposition seems to be due to the likelihood of accidents and to the fact that they feel breech deliveries nonhazardous. The latter fact is not borne out by statistics. As to the likelihood of accidents, this should be investigated. We find very few accidents reported in the modern literature. Adair<sup>4</sup> reporting a review of 1105 cases (nine authors) found but two cases of slight vaginal bleeding which were of no consequence. Casalta<sup>5</sup> cited a case of abruptio placentae with stillborn infant in which he felt version was responsible. DeLee,<sup>6</sup> in commenting, thought such accidents could arise from predisposing causes i.e. toxemia, infarcts, or coincidental. He said that he had done hundreds of external versions with the loss of but one baby, this being due to the use of unwarranted force. L. Newell<sup>7</sup> summarizing a four year study of the routine use of external version at Boston Lying In Hospital (1161 cases) reported placental separation four times all of which occurred some weeks after the version. O'Dell<sup>8</sup> discussed three cases of premature separation of the placenta, with one maternal death and a stillborn infant. Necropsy revealed a Cornu uterine. He cited a hypertensive case in which external version was done, reversion occurred and a second attempt at external version failed. The patient was then anesthetized and a third attempt at external version, plus a bipolar version attempt, failed. The patient was then given a pituitrin induction of labor, after which an emergency subtotal hysterectomy was done. The placenta was found to be three fourths separated. This case could have been due to manipulation, but the hypertensive state and other factors also may have played a part. This patient recovered. Ryder<sup>9</sup> had one case of slight vaginal bleeding where force was used under anesthetic.

Studdiford,<sup>3</sup> in a discussion of Ryder's paper, told of one case of external version followed by a complete separation of the placenta twelve hours later. He said that external version was from 50 to 60 per cent successful at Bellevue. Cosgrove<sup>3</sup> said he had one abruptio placentae where the attachment was low. B. P. Watson<sup>3</sup> claimed he had done external version for many years, that he had no fear of separation of the placenta or of uterine damage unless force was used. He had seen no compromised babies.

Flew<sup>9</sup> had a patient who went into labor fourteen hours after external version done at thirty-five weeks. McCullough<sup>10</sup> reported four cases of ruptured uterus in multiple presentations (head and feet) believed due to external version. Murray<sup>11</sup> said there were four multiparas arriving at the hospital with ruptured uteri after external version for malpresentation. Three of the women died. White

and Flew<sup>11</sup> claimed that six cases out of ninety-two that were anesthetized bled

M V Trubkovitch and R A Archangelsky<sup>12</sup> had 324 cases of breech, transverse and oblique presentations They had a total of 247

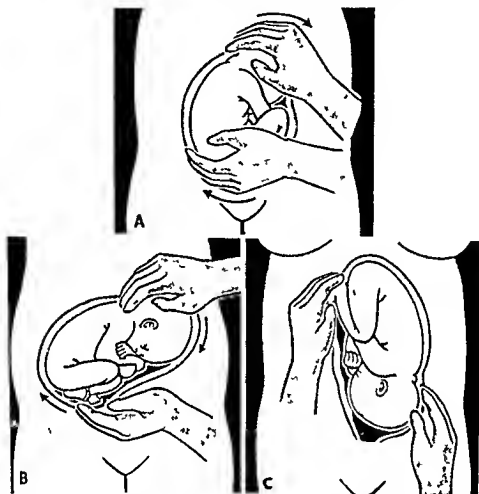


Fig 534—External version *A*, While one hand lifts the breech out of inlet into one iliac fossa the other hand presses the head downward toward the other fossa. As version progresses the abdominal wall is permitted to slip beneath the fingers *B*, Rotation continues and the fetal long axis approaches the transverse diameter of the uterus *C*, Version is complete. The head presents at the inlet, and if it engages easily it is likely to maintain the position. The turning of the baby is not a continuous movement but an intermittent one, and is suspended during a uterine contraction. The baby should be turned in the direction that maintains flexion. If this fails the turning should be attempted in the opposite direction. The fetal heart should be checked frequently. (From McCormick, Charles O. A Textbook on Pathology of Labor, the Puerperium and the Newborn. C. V. Mosby Co.)

deliveries after external version with three stillbirths (1.2 per cent). Premature labor occurred in 1 per cent after version and there was only one hemorrhage in the 324 cases.



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# BLOOD, BLOOD DERIVATIVES AND BLOOD SUBSTITUTES IN OBSTETRIC AND GYNECOLOGIC PRACTICE

WARREN R. LANG, M.D.\*

DURING the recent war there was a rising flood of literature on the use of blood, its derivatives and its substitutes. That increasing interest in these materials will benefit more than military medical practice is readily apparent.

Obstetrics and gynecology, especially the former, frequently present acute emergencies necessitating the immediate and efficient use of these products. Such exigencies as central placenta praevia, ruptured ectopic pregnancy and obstetric shock require the prompt administration of some type of parenteral fluid. Chronic states as anemia, puerperal sepsis and genital tract malignancies also benefit by similar therapeutic measures. Each of the three prominent causes of obstetric mortality—hemorrhage, infection and toxemia—is favorably affected by such treatment, but only recently attention has been directed to the role of blood, its derivatives and substitutes of the appropriate variety and quantity in the prevention of gynecologic deaths.<sup>1</sup>

This paper is an attempt to stress well established principles concerning their use and, avoiding controversial issues in the literature, to mention and evaluate the old and the new agents in this important field.

It is possible to classify the various substances as follows:

1. Blood—modified or unmodified
2. Blood derivatives—red cell suspensions, plasma, serum, human albumin, etc.
3. Blood substitutes (of two kinds)
  - (a) Colloidal—acacia, gelatin, bovine albumin, ascitic fluid, etc.
  - (b) Noncolloidal—saline, glucose, sucrose, amino acid mixtures, etc.

## METHODS OF ADMINISTRATION

Ordinarily, the oral route is the most desirable and most physiologic route for the administration of fluids. Obviously, it is necessary to choose some other method when fluid is needed rapidly, when intra-peritoneal infection exists, when vomiting or unconsciousness is present, or when the patient has only recently undergone major surgery.

By the *intravenous* route, most commonly utilizing the veins of the forearm or those of the antecubital space, one can furnish material available for instantaneous use. Colloidal or noncolloidal, isotonic or hypertonic solutions may be administered. Although it is rarely necessary to cut down on a vein (simple venipuncture being the ordinary

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procedure), sterile equipment for exposing a vein is indispensable when profound shock is present and the veins are collapsed.

Isotonic solutions may be given by *hypodermoclysis* either in the submammary regions or lateral aspect of the thighs. Absorption however, is slow and therefore inadequate for acute emergencies. The method is uncomfortable and restricts movement. Infection may occur. This mode of fluid replacement imposes very little stress on the cardiovascular system and here it finds its greatest usefulness.

When veins are poor or the patient is so restless as continually to dislodge the needle and when rapid absorption into the blood stream is required, the *intramedullary* route is described by Tocantins<sup>1</sup> should be resorted to. Through a needle inserted into the marrow of the manubrium or body of the sternum, fluid can be injected or infused into the general circulation. Under ordinary conditions the venous sinuses of the marrow will take up fluid nearly as rapidly as a vein without appreciable discomfort.

The *intraperitoneal* route has found its greatest applicability in pediatric practice but may occasionally be used in adults. Almost any isotonic solution, including blood, may be given. It is contraindicated in instances of infection, distention and multiple adhesions.

*Proctoclysis* has the main disadvantage of providing only slow water absorption. It no longer has many advocates. Fluids may also be given by the *intra arterial* route. Such a procedure theoretically imposes only minor strain on the right side of the heart. This method however is fraught with danger.

## BLOOD

The idea of transferring blood from one human being to another has intrigued medical men for centuries. The lot of stimulating real interest in this field, however, fell to James Blundell, a London obstetrician, who in 1818 treated severe and overwhelming postpartum hemorrhage with the infusion of blood. Since that time, especially in the last twenty five years, the use of blood has become commonplace and the development of blood banks has further served to stimulate such practice.

The purpose of giving blood may be to (1) increase blood volume, (2) increase coagulability, (3) improve the oxygen carrying capacity, (4) furnish proteins, (5) supply various immunological fractions and (6) possibly stimulate hemopoiesis.

Always assuming of course that proper typing and cross typing have been performed, blood may be prepared and given in several forms and by various methods. A *direct transfusion* or one by which the blood is transported directly from donor to recipient is given by vessel anastomosis or cannula. Technically, this procedure has many pitfalls, the outstanding one being coagulation. The *indirect transfusion*

is one in which blood is transferred from donor, thence to some storage vessel then to the recipient. Either *modified blood* (e.g., defibrinated or citrated or heparinized blood) or *unmodified blood* kept in special containers (e.g., paraffin-lined) is used.

The *indications* for the transfusion of blood in obstetric and gynecologic practice are listed in the following table.

# 1 Hemorrhage

## (a) Acute

- 1 Incomplete abortion
- 2 Ruptured ectopic pregnancy
- 3 Premature separation of the placenta (abruptio placentae)
- 4 Placenta praevia
- 5 Rupture of the uterus
- 6 Inversion of the uterus
- 7 Cervical lacerations
- 8 Postpartum uterine atony
- 9 Postoperative bleeding (internal or external)

## (b) Chronic

- 1 Hypermenorrhea and polymenorrhea
- 2 Submucous fibroids
- 3 Genital tract malenancies as cervical carcinoma and chorion epithelioma

# 2 Anemias

## (a) Those peculiar to pregnancy

## (b) Those associated with carcinoma without bleeding

## (c) Those associated with infection as puerperal sepsis, pyelitis

# 3 Shock both traumatic and hematogenic

# 4 Pre- and postoperative therapy as for cesarean section, "poor risk" patients

# 5 Hypoproteinemia as in carcinoma severe vomiting

# 6 Preeclamptic and eclamptic toxemia

Serious sudden hemorrhage is not foreign to the life of the busy obstetrician and gynecologist. In severe hemorrhage the cellular as well as the fluid elements of the blood are lost and in this instance the rationale of the transfusion of whole blood is obvious. Needless to say, one pint of whole blood is not always sufficient. The clinical response on the part of the patient is probably the best indicator as to when enough has been given. This should be checked and correlated with the usual laboratory determinations. Plasma and other substitutes are only supportive agents in marked hemorrhage. They are of slight value if the circulating blood is being continuously and speedily lost since not only must the blood volume be replenished but also the oxygen-carrying capacity must be supplemented with erythrocytes. One is confronted more than occasionally as to whether or not to give blood for a moderate postpartum hemorrhage. With massive bleeding there is no doubt but with lesser amounts one must constantly recognize that what may be a minor blood loss for one patient may have serious consequences to another.

It may be well to cite here the case of a woman whose life was

probably saved by the administration of large quantities of blood and plasma

H. M., a Negro aged 37 years, Para I Gravida II (case from the Ward Service of Dr. Norris W. Vaux)

This patient, a regular clinic patient was seen in the outpatient department on May 28, 1945, at which time a diagnosis of possible threatened abortion or tubal pregnancy was made. She was immediately admitted to the ward where her blood pressure became unobtainable and signs of peritoneal irritation became more prominent. One hundred cubic centimeters of five times concentrated plasma and 500 cc. of blood were administered. The patient was then taken to the operating room where under continuous spinal anesthesia a left salpingectomy for a ruptured tubal pregnancy was performed. More than 1500 cc. of fresh blood was found in the peritoneal cavity. During and following the operation 1500 cc. of blood was given. Although the patient did poorly while on the operating table she slowly improved while being transfused. She was discharged well on her eleventh postoperative day.

In such a case as this one must assume that merely arresting a bleeding point would not have been sufficient. Without blood and plasma her chances for survival would have been extremely slim.

Many gynecologic patients with longstanding disorders such as fibromyoma uteri and chronic pelvic inflammatory disease are anemic. If the hemoglobin is lower than 60 per cent or the red cells less than 3,000,000 per cu. mm., we routinely transfuse such patients preoperatively and if necessary, postoperatively too.

Special types of transfusion deserve only passing mention. *Auto-transfusion* is the reintroduction of the patient's own blood collected from external bleeding or from a serous cavity as the peritoneal space. This procedure has rarely been used in postpartum bleeding and occasionally in ruptured ectopic pregnancy. *Autotransfusion of irradiated blood* has been infrequently administered in the therapy of neoplasms and infections. *Immunotransfusion* or the transfusion of blood from a donor previously immunized has been tried in puerperal sepsis with equivocal results. *Cadaver blood* has been used by the Russians. It has not received much favor in this country. The employment of *placental blood* is relatively new.

**The Rh Factor**—While the actual giving of transfusions is a simple intravenous procedure, various complications may arise.

Of special interest to obstetricians and gynecologists however is the discovery of the Rh agglutininogen by Landsteiner and Wiener in 1940.<sup>2</sup> This factor is of special importance in hemolytic transfusion reactions, certain complications of pregnancy and neonatal anemias. It is called Rh because it was found in the red blood cells of the rhesus monkey. Subsequently, it has been demonstrated in the erythrocytes of 87 per cent (Rh positive) of the white population and found to be absent in 13 per cent (Rh negative). It is the latter group which bears the brunt of undesirable sequelae of the Rh factor.

Usually, sensitization to the Rh agglutininogen occurs only in Rh negative individuals. Such persons are sensitized by one or more

transfusions of Rh-positive blood or by one or more pregnancies with Rh-positive infants. On the other hand, that there may be sensitization to the Rh agglutinin in Rh-positive patients has been demonstrated by Levine.<sup>4</sup> This is due to the existence of Rh subtypes. The most frequent cause of intragroup transfusion reactions in Rh negative individuals is that the donor is Rh positive and that previous transfusions of Rh-positive blood or the bearing of Rh-positive babies caused the immune response. In the case of erythroblastosis foetalis the most common findings are an Rh-positive fetus, an Rh-positive father, an Rh-negative mother and often a history of previous pregnancies or transfusions with Rh positive blood.

It is theorized that the red cells of the Rh-positive fetus enter the maternal circulation and stimulate the production of maternal anti-Rh agglutinins which in turn traverse the placental barrier into the fetal circulation and produce erythroblastosis foetalis.

The practical application of the above may be summarized as follows. No woman, no matter what her age group, should be given Rh positive blood unless her Rh status has been determined. If necessary, plasma should be used until proper blood is available. Whether the erythroblastotic baby may receive Rh-positive blood is still a problem for more detailed study.

The following is a case illustrative of the importance of Rh determination.

J. F., aged 28 years, of Italian descent (private patient of Dr. Mario Castallo)

In 1941, following six hours of hard labor with ruptured membranes, the patient had a low cesarean section for cephalopelvic disproportion. At this time she received one blood transfusion without any untoward results. Both mother and baby did well. The patient became pregnant for the second time and in June 1945, the same type of cesarean section was done. During the operation the patient received one pint of Rh positive blood. On the day following delivery the baby became very icteric and, on testing, was found to be Rh positive while the mother was discovered to be Rh negative. Three transfusions over a period of four days were given. A few days after the cesarean section jaundice, edema, fever, mild irrationality and signs of peritonitis appeared in the mother. On one occasion her nonprotein nitrogen was 190 mg. per 100 cc. of blood, and the proteins 39 per cent. Transfusions of Rh negative homologous blood and penicillin were given. Both mother and child slowly improved.

In this case one can only conjecture what may have happened had the obstetrician persisted in giving Rh positive blood to the mother. As it is, the woman has now been sensitized to the Rh factor by both transfusions and at least one pregnancy (the latter one), either of which is sufficient to jeopardize further pregnancies.

#### BLOOD DERIVATIVES

**Red Cell Suspensions**—A recent addition to the armamentarium of the clinician is the red blood cell suspension in either natural or higher concentration as is found in the average human blood. This product

has recently been utilized as supportive therapy in menorrhagia<sup>5</sup> and its value in supplementing the treatment of anemia, including erythroblastotic anemia is evident. The economic advantages are important since red blood cells, formerly discarded from the preparation of plasma, can be put to use.

Erythrocyte suspensions should be given when red cells are all the patient needs from transfusions. In such a case as anemia with cardiac complications, one may combine the cells from two pint donations into one transfusion, thus eliminating two separate transfusions and the administration of unnecessary fluid. The increase in erythrocyte count following the transfusion of cells from one pint of whole blood is equal to that resulting from the transfusion of an equivalent amount of whole blood. Greater increases can be obtained with more concentrated solutions. Red cell suspensions provide a more rapid return to favorable hematological values than does the use of iron and liver preparations.

Group O cells may be used for the recipients of other groups when homologous cells are unavailable. The cells of Rh negative donors, even though the plasma of such donors might contain anti Rh antibodies, may be safely given to erythroblastotic infants or to the mothers of such children. In general, reactions are less frequent with cell suspensions than with whole blood. The use of such therapy certainly deserves a definite role in obstetrics and gynecology.

**Plasma and Serum.**—*Plasma* is essentially the liquid portion of the blood separated from the cellular elements without clotting and may be regarded as a liquid solution of albumin, globulin and fibrinogen. It has gained more popularity than *serum*, which is the liquid component of the blood after coagulation has occurred. At present the relative merits of plasma and serum are still under debate. Both, however, are human, colloidal, protein containing fluids. The former can be prepared in three forms: liquid, frozen and dried. Of great importance is the fact that dried plasma can be concentrated. In contrast to serum, plasma contains more protein, can be made from outdated stored blood and gives rise to less reactions. Serum, on the other hand, need not contain citrate and does not precipitate fibrin during storage as liquid plasma may do.

Strumia and McGraw list the particular advantages of plasma over blood<sup>6</sup> (1) freedom from reactions except urticaria, (2) plasma may be administered in larger amounts, (3) plasma may be concentrated if desired, (4) since no typing and cross-typing are required if pooled plasma is used, time is saved and (5) plasma transfusions do not augment hemoconcentration.

The most frequent and significant use of plasma transfusions in obstetrics and gynecology as in other branches of medicine is in the treatment of *shock*. In this condition the proteins of the plasma are of prime importance and the cellular components of relatively little

note The shock syndrome, with accompanying hypoproteinemia, may follow bleeding as with postpartum hemorrhage or a ruptured ovarian cyst or occur in infections as acute peritonitis or following such intra uterine manipulations as internal podalic version and the like Plasma is ideal for replacement therapy in these conditions However, plasma is often administered "too little and too late—and too slowly It should be given until the sensorium, pulse and blood pressure approach normal The dose is 'enough' to accomplish just this

Although shock is the prime indication for plasma transfusion, this blood derivative is of supplemental value in other states in nutritional hypoproteinemia, as in hyperemesis gravidarum, in carcinoma with ascites where there is protein loss into the peritoneal cavity in acute yellow atrophy where protein synthesis is impaired in post operative, nonobstructive abdominal distention, in marked infections in faulty wound healing, in hypotension concomitant with spinal and caudal anesthesia, in severe preeclampsia and in eclampsia

In chronic hypoproteinemic conditions, however, one must not be enticed into attempting cure by plasma transfusions alone Ingested food is still the most preferable for protein restoral Intravenously administered protein is very difficult to give in amounts sufficient to meet daily requirements Under ordinary conditions the concentration of plasma is so low (5 to 6 gm per 100 cc) that large quantities of isotonic plasma are necessary to correct even a slight protein deficit It is calculated that about 1000 cc of plasma (equivalent to 4 pint blood donations) are needed to raise the plasma protein level 1 gm per 100 cc of circulating blood

### BLOOD SUBSTITUTES

Colloidal Plasma Substitutes—Many substitutes have been proposed by various investigators No attempt will be made to discuss each one exhaustively Koop has listed certain criteria for the ideal plasma substitute<sup>8</sup> These are physical properties—stability, low viscosity, high osmotic pressure, colloidal particles so large that they are retained in the circulation, physiologic properties—safety of injection in large quantities, no interference with coagulation or defense against infection or tissue repair, no effect on internal organs, immunologic properties—no antigenicity and no natural sensitivity to similar substances such as sera or foods To these requirements might be added inexpensiveness and ease of preparation

*Albumin* comprises approximately 60 per cent of the plasma proteins and exerts 85 per cent of the osmotic pressure provided by normal human plasma One hundred cubic centimeters of a buffered saline solution of 25 gm of human albumin exerts the same colloidal osmotic pressure as 1000 cc of whole blood or 500 cc of normal plasma This is very advantageous in shock therapy The reduction of bulk with the use of such concentrated solutions is of even greater impor-



tance. Ample fluid should be given along with albumin should dehydration also be present.

Attempts to use *bovine albumin* fractions are now in progress. Reactions are frequent however and the work is still experimental.

*Gelatin* solutions have previously been subjected to much criticism since reactions, some fatal, have occurred. Newer sources and methods of preparation have obviated most of these difficulties.<sup>7</sup> However satisfactory gelatin may be for shock, it must be remembered that gelatin is lacking in many essential amino acids and is therefore unsatisfactory as a source of protein for purposes of nutrition.

*Acacia* (gum arabic) is not a protein but it possesses the ability to raise the colloidal osmotic pressure as do albumin and gelatin. Liver damage and even death have been reported following its use.

*Pectin*, a colloid carbohydrate derived from fruits and vegetables is supposedly nonantigenic. Its applicability in the treatment of shock and other conditions awaits further evaluation.

*Ascitic fluid* (1 to 2.5 per cent protein) is readily available in any hospital where patients are suffering from chronic cardiac decompensation and hepatic cirrhosis. Pooling is desirable. There is a minimum of danger and few reactions are associated with its employment.

**Noncolloidal Plasma Substitutes**—Normal saline solution either intravenously or by elysis, is given almost routinely to patients immediately after major surgery. As such it serves to correct the dehydration resulting from the operation and may also provide a medium for vitamins, amino acids and the like. When there is a latent tendency to edema as in preclampsia, malnutrition or cardiac disease, its use is ill advised.

*Glucose* is of extreme importance in body metabolism. A liver rich in glycogen resists the action of toxic agents better than one deficient in glycogen and thus glucose solutions are given in both the early and late toxemias of pregnancy. Hypertonic solutions (10 to 50 per cent) are given in hypertensive toxemias to decrease cerebral edema and promote diuresis. We have recently seen the passage of copious quantities (2000 cc per day) following the administration of hypertonic glucose solutions to a woman with ureteral blockage following irradiation therapy for carcinoma of the cervix.

Intravenous hypertonic *sucrose solutions* are used as hypertonic glucose solutions. Sucrose is excreted in the urine unchanged. It has nephrotoxic properties.

As is well known, the above crystalloids are of little value in the correction of shock since they rapidly diffuse into the tissue spaces.

*Amino acids* have been administered intravenously, subcutaneously into the bone marrow and by rectum. When their intravenous injection is too rapid, severe reactions attributable to hyperaminoacidemia may ensue. To cause a significant change in the plasma proteins large quantities are needed.<sup>8</sup>

## COMMENT

It is well at this point to emphasize again that parenteral fluid therapy is not a completely innocuous form of treatment. Undesirable reactions may occur from either the apparatus used or the agent administered. The frequency of these reactions is in inverse ratio to the knowledge of the therapist and the competency of the laboratory. The Rh factor, a familiarity with which is so essential for the obstetrician and gynecologist in this respect, has already been described. Moreover, the mere giving of, for example, blood or plasma does not excuse the physician from employing purely surgical or medical means of cure.

As for the parenteral fluids themselves, progress in their preparation and evaluation is rapid and only time can disclose how much safer and more effective they will become.

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for a high death rate from asphyxia is the use of deep analgesia and anesthesia. Narcotics and hypnotics are respiratory depressants and enter the fetal circulation by diffusion through the placenta. Eastman<sup>3</sup> has given the following figures: with no analgesia or anesthesia 98.1 per cent of the babies breathed immediately, with nitrous oxide ether and oxygen 88 per cent, and with barbiturates, scopolamine, rectal ether or paraldehyde only 50 per cent. The effect on premature infants was especially bad.

With the advent of spinal and caudal anesthesia there has been a marked decrease in fetal asphyxia. Hingson and Lull<sup>4</sup> report that the use of these methods gives the infant the same maximum safety as if no analgesia or anesthesia were used.

In any case in which an increase in fetal heart rate becomes abnormal prior to delivery, the mother should be given repeated oxygen inhalations to decrease the severity of the anticipated asphyxia. The immediate treatment of asphyxia is to insufflate the lungs with oxygen by some form of resuscitation. Before any such measures are used an open airway must be obtained by aspiration of amniotic fluid and mucus from the pharynx and trachea. In some cases, particularly of the asphyxia livida type, this may be all that is necessary. In other mild cases some stimulation to the skin, such as rubbing the back or dropping a little ether on the baby, or snapping the feet may initiate respirations. Body heat must be maintained throughout any resuscitation procedures and gentle manipulation is important, for overtreatment or too vigorous treatment may cause more serious damage.

Severe cases of asphyxia due to intracranial hemorrhage will not respond to merely clearing the airways but need artificial respiration. These are the cases of asphyxia pallida characterized by complete loss of muscle tone and the appearance of shock. Positive pressure machines such as the Erickson-Johnston (E & J) have proved very valuable. In some instances the use of the Flagg apparatus is indicated. It makes use of direct visualization of the trachea by means of a small laryngoscope with subsequent insertion of a catheter for aspiration and the insertion of a small metal tube through which oxygen can be introduced under carefully controlled pressures. This should be used only by a trained operator as trauma and edema of the glottis may result. Simpler to do is the direct insertion of a catheter into the trachea in the same manner as intubation is performed.

Mouth to mouth insufflation still remains the most convenient form of resuscitation to use and is to be resorted to where mechanical devices are not available. It has fallen into disuse because of the difficulty in regulating pressures and the frequent complications of rupture of the lungs and pneumothorax which occurred. The Schaeffer method of manual artificial respiration is condemned because the principles on which it works require the presence of a once expanded

lung, which does not apply in these cases in which atelectasis is the rule.

There has been considerable controversy over the choice of gas to use in initiating respirations. Henderson<sup>5</sup> has maintained that oxygen and carbon dioxide mixtures are necessary but the more recent studies of Eastman and Kreiselman<sup>6</sup> indicate that asphyxiated babies are born with an excess of carbon dioxide in the blood and the condition is primarily one of anoxemia requiring pure oxygen. After respirations are established it may be beneficial to give occasional inhalations of the mixture to promote deep breathing.

The use of drugs to overcome asphyxia has proved disappointing in most instances, for efficacy depends upon a normally functioning circulation which is usually not present. Some authors believe they should be used only as a last resort as there is such a narrow margin between the minimum effective and lethal dosage. Alpha-lobeline in doses of 1 cc. is usually given direct into the umbilical vein but its effects are very transitory. Coramine in doses of 3 or 4 minims intramuscularly gives better maintenance and is particularly useful in overcoming barbiturate poisoning. Caffeine sodium benzoate 1 to 1½ grains may be of some value.

#### INTRACRANIAL HEMORRHAGE

Intracranial hemorrhage may be a factor in itself as a result of trauma or it may be associated with asphyxia or prematurity. It may occur from mechanical rupture of blood vessels or be due to a delay in blood clotting as a result of a decreased prothrombin content. With the advent of vitamin K there has been a marked decrease in the hemorrhagic tendencies of the newborn but it has no effect on hemorrhage due to gross trauma as manifested by cephalhematomas, ecchymoses or hemorrhages into the adrenals or liver. Vitamin K can be administered to the mother before delivery or to the infant as soon as it is born. It should be given to all premature infants and to the infant after breech deliveries or difficult and prolonged deliveries. A 2 mg. dose can be given intramuscularly immediately after birth and repeated every six hours for four doses if needed.

Supportive treatment in cases of intracranial hemorrhage consists of a minimum of handling, continuous inhalations of oxygen, feedings by gavage or clysis and free use of sedatives where twitchings or convulsions occur. Sodium phenobarbital is the drug of choice. Lumbar punctures should be done only if there is evidence of increased intracranial pressure and in some cases a cisternal puncture is less injurious to the child. Transfusions of whole blood are of value in massive hemorrhages and administration of hypertonic solutions intravenously may help decrease cerebral edema. The posture of the child is im-

portant as it should never be put in Trendelenburg position but should be kept horizontal or even with head raised

#### PREMATURE INFANTS

A premature infant is now considered as any infant weighing less than  $5\frac{1}{2}$  pounds (2500 gm) regardless of period of gestation. The immediate care of these infants is of vital importance for it has been shown that if these babies survive forty eight hours the mortality should be less than 15 per cent provided they receive proper care. However, 60 per cent of all deaths occurring in the first twenty four hours is due to premature births.<sup>7</sup> The causes of death are cerebral hemorrhage atelectasis and pneumonia. Immaturity is a factor in the lower weight babies and the incidence of congenital malformations adds to the high mortality rate, but aside from these two factors the other conditions are preventable to a certain extent. Good antepartum care and sound obstetrical judgment while not preventing prematurity will aid in producing infants uncomplicated by other hazards. Tyson<sup>8</sup> has stated that in the absence of maternal complications and where there is nothing intrinsically wrong with the baby, the small infant should do well under careful pediatric supervision and good nursing care.

The use of analgesia and anesthesia has had a marked effect on the mortality of premature infants. It is important to maintain a high concentration of oxygen in cases of prematurity and the consensus is that the avoidance of other than mild sedation and a minimum of anesthesia plus the careful use of low forceps with episiotomy, offers the best prognosis. Caudal anesthesia is probably the most ideal method to use but should be given only where adequate hospital facilities and trained supervision exists.

The principles concerned in the immediate care of a premature are dependent on the characteristics of these low weight babies. Maintenance of body heat is of great importance as there is an instability of heat regulation due to incomplete development of the center and the frequent occurrence of intracranial hemorrhage. There is also a predisposition to loss of body heat because of a relatively large body surface with little subcutaneous tissue and extensive vascularization of skin. The temperature of the delivery room should be between 70° and 75° F and as soon as the baby is delivered and the cord ligated it should be received in warm blankets and placed in a heated crib. Gentle aspiration and resuscitation methods if necessary can be carried out under these conditions. Regardless of whether the infant is asphyxiated or cyanotic it is considered advisable to give continuous oxygen the first hour or so following delivery. In the delivery room oxygen may be supplied through a mask attachment of the resuscitating machine or through a nasal catheter. In the nursery it is best ap

plied by means of an infant size plastic tent, if incubators are not available with oxygen attachments

An ideal arrangement in a hospital is to have special premature nurseries with air conditioning, separate cubicles and incubators for each baby. The temperature of the nursery should be maintained between 80° and 85° F with a humidity of approximately 60 to 65 per cent. Lacking such facilities the infants may be kept in specially heated cribs or, in emergencies in ordinary cribs lined with hot water bottles or heated by means of electric lights. However it is somewhat dangerous to use hot water bottles because of the danger of burning the infant as well as the difficulty in maintaining an even temperature. Babies under 4 pounds should be placed in a cotton jacket allowing only the head to be exposed. Body temperatures should be kept between 99° and 100° F rectally and should be checked every three hours until stabilization occurs then twice daily. Overheating resulting in a loss of body fluids is even more dangerous than a 1 degree drop in temperature.

Frequent attacks of apnea and cyanosis require the constant vigilance of a trained nurse. These attacks may be the result of aspiration of liquor amni or mucus at the time of delivery or they may be due to congenital atelectasis from immaturity of lung tissue or to underdevelopment or trauma of the central nervous center. They may be precipitated at the time of feeding and it has been found helpful to administer a 5 per cent carbon dioxide-oxygen mixture about two minutes before and after each feeding.

The baby should not be removed from its crib except for weighing every two or three days or at even longer intervals in the case of very small infants. Oil baths can be given in the crib and feedings do not require removal of the infant. The position of the body should be changed frequently to prevent a passive congestion of the lungs.

The feeding of premature infants requires a special technic as the sucking and swallowing reflexes are either weak or absent. Whenever it is obtainable breast milk is the food of choice but evaporated or powdered milks may be substituted. Nothing is given for twelve hours after birth or even for eighteen hours depending on the size of the infant and its general condition. Then 2 to 8 cc of 5 per cent lactose water with 3 minims of whiskey is offered every two hours. At the end of twenty four hours breast milk or a weak formula is started in amounts of 1 to 4 drams increasing the amount up to 1 ounce if retained and the interval to every three hours. The first feedings may be given by medicine dropper with the tip protected by rubber then progressing to a Breck feeder and bottle with soft nipple as the sucking reflex develops. In the babies whose reflex is very weak or absent or in those for whom the effort of nursing is too much of a strain, gavage feeding is indicated. In the hands of a trained nurse there is little danger of aspiration or trauma occurring. A No. 8 or No. 10 French cath

eter is used and the length to be inserted is measured from the tip of the nose to the ensiform cartilage

The daily estimated requirements of 70 to 80 calories per pound up to as high as 100 to 120 calories are too much for the first few days of life. Overfeeding may lead to a serious condition for if the gastrointestinal tract is upset in a premature the prognosis is unfavorable. It is advisable to start with small weak dilutions waiting for such favorable signs as no vomiting, normal stools and absence of distention before increasing. Since the total fluid requirement of  $2\frac{1}{2}$  ounces per pound usually cannot be met by oral feedings, parenteral fluids should be given. Since salt is excreted with some difficulty by the premature it is better to give Hartmann's solution or  $2\frac{1}{2}$  per cent glucose in distilled water rather than normal saline. Amounts of 20 to 40 cc given subcutaneously can be administered twice daily if necessary. During the first week no gain in weight may be expected but if no complications arise there is little to worry about.

The death rate of premature infants will probably be decreased if the following requirements can be met in each case: first and most important, expert nursing care; second, a suitable physical environment permitting proper maintenance of temperature and humidity; and third, a sound feeding procedure.

#### ERYTHROBLASTOSIS FOETALIS

In recent years the discovery of the Rh factor in the blood has caused us to be alert in the first few days of the newborn for any signs of jaundice or anemia with prompt treatment in suspected cases. Formerly the severe anemias were not recognized as early and transfusions were not as lifesaving as they are today. At present most obstetricians make Rh tests on prospective parents and the baby of an Rh negative mother is carefully checked. If transfusions are necessary it is advisable to give Rh negative blood from a donor other than the mother.<sup>1</sup> Very good results have been obtained from as few as three or four small transfusions, each consisting of about 10 cc of blood per pound of body weight. Since antibodies may be transferred through the colostrum and milk, these babies should not be permitted to nurse at the breast.

As yet no treatment prior to delivery can prevent the occurrence of erythroblastosis but some authors advise cesarean section several weeks before term in all suspected cases.<sup>2</sup> They point out that the infants are very susceptible to intrauterine asphyxia and that by doing a section under local anesthesia the stress of labor can be avoided.

#### INFANTS OF DIABETIC MOTHERS

The mortality of infants born to diabetic mothers is still considerable during gestation and the first few days of life. The neonatal deaths are believed to be due to a severe hypoglycemic reaction. Re-

ardless of the treatment of the mothers' diabetes during delivery, it is considered advisable to give the infant 10 cc of 10 per cent dextrose in water immediately after birth and every one or two hours for the first few days in addition to its regular feedings<sup>10</sup> If this is not retained by mouth a more dilute solution can be given subcutaneously. It is usually three or four days before these infants maintain a normal blood sugar

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